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The Fifty-Fifth Meeting of the American Astronomical Society

By FRANCES LOUISE SEYDEL

The American Astronomical Society held its Fifty-Fifth Meeting at Princeton University, Princeton, New Jersey, on December 26-29, 1935.

Thursday evening, December 26, saw the advance guard arriving by car and by rail. Although speed and space and companion words are frequently used in the literature of astronomy, the astronomers seemed quite land-bound in their mode of travel to and from the Princeton meeting. We heard of no astronomer arriving or departing by plane. All told there were approximately 120 persons in atendance.

Thursday evening was most informal. The members and their families congregated in the large living room of the Princeton Inn for delightful talks with old and new friends.

The meetings were held in a large lecture room of the Frick Chemical Laboratory. In all 43 papers were presented or read by title before the Society in its four sessions for papers—Friday morning and afternoon, Saturday morning and afternoon. Interesting discussions followed the presentation of each paper. An astronomer—we withhold his name—made his first appearance at the meeting on Friday morning when Professor Stewart was speaking on "Irregular Variability." The title sounds extremely astronomical, but this paper was the exception that proved the rule. The piece of experimental apparatus was a roulette wheel. The astronomer appeared at the moment when the roulette wheel was not only in evidence but in operation. The room was dark when he entered. He saw the spinning roulette wheel, and, greatly bewildered, leaned over to the gentleman seated nearest him, and whispered, "Isn't this the Meeting of the American Astronomical Society?"

At the close of the session on Friday morning, President H. W. Dodds, of Princeton University, welcomed the American Astronomical Society to Princeton. Immediately after this the Society as a group moved to a convenient location for the making of the official photograph. It was cold. A chilly wind was blowing. The East was trying very hard and succeeding in making the Middle Westerners feel at home by having zero weather.

After adjournment of the Friday afternoon session the members and friends of the Society were guests for tea at the Student Observatory. Delicious refreshments were served by the hostesses, Mrs. Russell, Mrs. Dugan, and Mrs. Stewart. After the tea the Society made a pilgrim-

age to the New Observatory. This is a fine new observatory housing the 23-inch refractor which has been remounted. The members made a complete tour of the building.

We had luncheon and dinner on Friday and luncheon on Saturday at the Campus Club. Friday evening after dinner a contest was held to determine the Best-All-Round-Observatory. The test was divided into two parts: "critical" and "theoretical." For the critical part, the representatives from the different observatories were handed sheets of paper listing fifteen statements to be marked "corrct" or "incorrect." To prevent mere guessing, the score was +1 for "correct" and —2 for "incorrect." The following are typical of the statements:

> If the moon were made of green cheese and arithmetic were all, then, if twenty maids in twenty days can make two hundred and seven tons of cheese, five million W.P.A. workers in one hundred thousand years could not make half the moon.
>
> The statement "Annuit coeptis novus ordo seclorum" is taken from Sir Isaac Newton's explanation of precession and nutation.
>
> Excluding the sun, there is no star known nearer than three thousand million million million million angstroms.

The first statement is correct and the last two are incorrect. The second is the motto on the new one-dollar bills just issued! The nine observatories rating highest in this critical test then took part in the theoretical test. Those present took positions around the outer part of the dining room, leaving the nine contestants in the center. These persons were divided into three groups of three each. And now everything was ready for the great theoretical test! Three white bowls, each containing three green peas, were placed upon the floor at one end of the dining room. A soda-fountain straw was given to each of the first three contestants. The problem proposed was the transportation, by suction, of the peas from one end of the room to the other. When the scores for both the critical and the theoretical tests were finally computed, Professor Stebbins succeeded in winning for Washburn Observatory the title of Best-All-Round-Observatory. Professor McLaughlin showed the University of Michigan to be the Second-Best-All-Round-Observatory.

We then returned to the large living room where further entertainment awaited us, "The Harvard Follies of 1935." All the persons in the cast were from Harvard Observatory and Dr. Shapley acted as "M.C." (master of ceremony). First on the program was S. Chandrasekhar who told several very delightful anecdotes. The next part of the program consisted of some Dutch songs, sung by Drs. Kuiper and Mülders. The "M.C." introduced them as Lawrence Tibbett and John Charles Thomas singing, "Wink at me with one eye and I will wink at you with two." The third act on the program was Houdini in the person of Dr. Whipple. The entertainment ended with a number by the Harvard Chorus. The whole evening was fun and laughter, a pleasant interlude between the two days of sessions devoted to papers.

Saturday morning a new word was added to the writer's vocabulary as the result of hearing Professor Curtis read the paper on "The New Solar Tower of the McMath-Hulbert Observatory." She offers no apologies if it is mis-spelled. It is the name of a new piece of apparatus, and is—spectroheliocinematograph.

At the close of the last session on Saturday afternoon Professor Stebbins proposed, on behalf of the Society, a resolution of thanks to all of those who had had a part in planning and carrying out the arrangements for our delightful stay in Princeton. The resolution was adopted by acclamation. Professor Stebbins also said that he thought he had come the greatest distance, 1,000 miles, to attend the Meeting. The writer wishes to say that she can top this figure, because she traveled 1,350 miles.

The Council met several times for business sessions. There was no business brought up before the Society. The following are the names of the new members:

Haupt, Ralph Freeman, 2301 Cathedral Ave., N.W., Washington, D. C.
Heck, Dr. Nicholas H., U. S. Coast and Geodetic Survey, Washington, D. C.
Jose, Paul D., 1308 East Ann Street, Ann Arbor, Michigan.
Kuiper, Prof. Gerritt P., Harvard College Observatory, Cambridge, Mass.
Rice, Hugh Smith, American Museum of Natural History, New York City.
Taylor, Miss Alice E., Whitin Observatory, Wellesley, Massachusetts.
Whitford, Dr. Albert E., Washburn Observatory, Madison, Wisconsin.
Whitney, Balfour S., Flower Observatory, Upper Darby, Pennsylvania.

The members were reminded that the next meeting of the Society is to be held at Harvard University in September. As Harvard University will be celebrating its Tercentenary Anniversary, this meeting should be most interesting. The Christmas Meeting will be held at the Naval Observatory, Washington, D. C., in connection with the meeting of the American Association for the Advancement of Science. The following September, Williams College will be host to the Society.

Professor Slocum presided at the meeting on Saturday afternoon: Professor Russell presided at all other times. The familiar figure of Professor Dugan was greatly missed. He was unable to be present on account of illness. It was especially unfortunate that he was detained from the meetings held at his institution.

The final gathering of the Society was the banquet on Saturday evening at the Graduate Club. We assembled for conversation before and after dinner in the beautiful, large living room. For dinner we entered the high vaulted dining hall to the strains of organ music and grouped ourselves at three long tables. Professor Russell headed one table. On his left sat Dr. Shapley, on his right sat Professor Einstein, and next to Professor Einstein sat Professor Brown. After dinner Mr. Rudy played two numbers on the organ. Then Professor Einstein, accompanied on the piano by Mr. Rudy, played three selections on the violin. One of the truly high points of the Meeting was the presence of Professor Ein-

stein on this Saturday evening. He has the most magnetic, endearing personality. His voice is gentle. One feels the inner poise and quietness of real greatness. This was a wonderful end to a most interesting and valuable meeting. Every one who attended is grateful to the Princeton astronomers and other members of the staff for their gracious hospitality which added greatly to making this meeting such a fine success.

GOODSELL OBSERVATORY, NORTHFIELD, MINNESOTA.

Long-Period Variable Stars and the Stellar System

By PAUL W. MERRILL

(Eighth and last in a series of articles)*

The stars are separated from each other by the appalling chasms of interstellar space, and, except in special cases, their interactions appear to be as slight as those of a few marbles rolling about the floor of a skating rink. Great cosmic forces controlling their characteristics and behavior are not easily recognizable. The observational picture of a star is largely that of an independent unit pursuing its way with little interference from its neighbors or the galactic federation. Groups of stars, it is true, often exhibit similar motions or have other characteristics in common but the causal influences are not in evidence. Any close connections which may once have existed between various stars have been obscured by time immemorial and now lie hidden under the cloak of apparent independence. This is particularly true of long-period variables. These objects, many of which have essentially identical properties, scattered over the face of the sky without obvious system, exhibit little allegiance to the plane of the Milky Way; they have large random space motions; and the cause of the light variation of each individual appears to be intrinsic.

It is highly improbable, however, that each star is a closed kingdom of its own, created and formed in isolation, having no kinship whatsoever with other bodies. Our galaxy is certainly homogeneous in its fundamental properties, and we firmly believe that the stars do form a system, some members of which, at least, must in the past have had very intimate relationships. The historical development of the various components of this system is usually called stellar evolution, but the word should not be taken in the biological sense, for we are concerned with the life history of individual objects, not with the gradual variation of a species through successive generations. One generation of stars is all that is available to scientific study, and one is enough to keep us busy for some time.

*For preceding papers, see February, May, and October (1929), March (1931), April (1933), April (1934), and April (1935), issues of this publication.

The story of our knowledge of stellar evolution is a sad one of small successes and large blunders. Following Laplace, astronomers believed that stars condensed from nebulae; that they were originally very hot and that their lives were spent in cooling off. Next we were told that the youngest stars were tenuous, low-temperature objects (red giant stars); that for a time they become hotter by condensation until a certain physical condition is reached after which (as dwarf stars) they cool by radiation. At present most astronomers admit almost total ignorance concerning stellar life histories. Students of stellar evolution have passed through the stage of the freshman who knows not, but knows not that he knows not, into the more hopeful condition of the sophomore who knows not, but knows that he knows not. Perhaps in a few hundred years junior and senior standing may be achieved.

In discussing the relationships between long-period variables and other astronomical objects, therefore, we cannot at present have the coordinating assistance of a general theory of stellar evolution. Instead we must endeavor to find, in the numerous well established facts concerning long-period variables, guidance in forming such a theory.

For the present purpose our knowledge of long-period variables may be considered under three headings: *a*) physical characteristics, *b*) distribution, *c*) motions.

Physical Characteristics

As some description of the best known characteristics of long-period variables has previously been given,[1] the present article is limited to discussing the relationship of these characteristics to those of other stars. If various types of stars are arranged according to their surface temperatures, as in the usual spectral classification, O, B, A, F, G, K, M, the position of long-period variables is well marked: they clearly occupy the low temperature end of the sequence. In the Russell diagram (Fig. 1), in which absolute magnitude is plotted against decreasing effective temperature (or type), long-period variables lie at the right hand extremity of the group of giant stars. Toward this (low-temperature) end of the group the proportion of variable stars increases rapidly; most stars of class M6 and practically all stars of more advanced spectra are variable. The dwarf branch contains no known long-period variables. The long-period variables of classes M6e to M8e (or of the later subdivisions of class N) are therefore the coolest stars known. Their effective surface temperatures are about 2300° C absolute at maximum, 1800° at minimum.

Do still cooler stars, although undetected, actually exist? The first thought might be that, as the effective temperature decreases, the luminosity also decreases, so that the cooler stars are simply too faint to come within the range of present observations. This appears to be a satisfactory explanation of the apparent absence of cooler *dwarf* stars, for

[1] Popular Astronomy, **42**, 180, 1934.

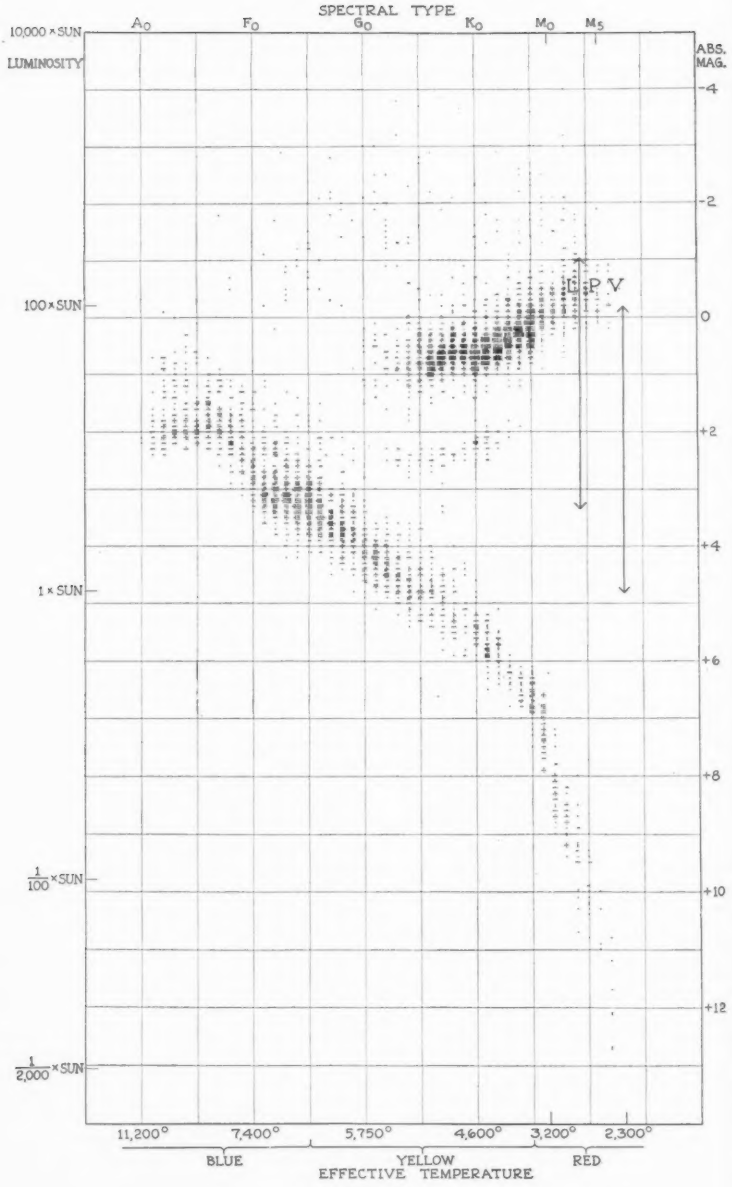

FIGURE 1

LUMINOSITIES AND EFFECTIVE TEMPERATURES OF THE STARS

Adapted from a diagram in *Mt. Wilson Contr.*, No. 511; *Ap. J.*, **81**, 187, 1935. Several hundred long-period variables would appear near the letters L.P.V. The light-range is indicated by arrows.

along the dwarf branch decreasing brightness goes with advancing spectrum and decreasing temperature, as we might expect of dense objects (see Fig. 1). The lower limit of known temperatures for dwarf stars is probably set by the faintness of the stars and the difficulty of detection rather than the actual absence of cooler stars. It seems quite possible that the more complete observations of the future will disclose cooler and fainter dwarfs than any in the present lists, and that these objects will form a smooth continuation of the series now known.

These considerations do not apply equally, however, to the sequence of giant stars. For in passing along this sequence from class G to class M6, there is an increase, instead of a decrease, in visual luminosity, while the total radiation increases even faster. The interpretation is that increasing dimensions of the stars more than compensate decreasing surface brightness.

The giant sequence seems to terminate abruptly with long-period variables whose temperatures at maximum are between 2000° and 2300°. In marked contrast with the dwarf stars, there is no striking tendency toward faintness even near the extreme end of the known sequence. The apparent magnitudes, for example, show no decided decline. Twenty-four long-period variables are listed as being brighter than apparent magnitude 6.0 at maximum, while hundreds brighter than the tenth magnitude are known. Statistical investigations show definitely that long-period variables as a group have high luminosities, although there is an indication that objects of types M5e to M8e are slightly fainter than those of types M1e to M4e.

Observational data competent to disclose cool stars seem to point strongly toward an actual discontinuity, either in luminosity or in frequency, in the giant sequence just below long-period variables of class M8e. Since the position of maximum spectral energy moves into the infra-red with decreasing photospheric temperature, in searching for exceptionally cool stars there will be a strategic advantage in using the longest wave-lengths that photographic emulsions permit. Several special investigations using red or infra-red light[2] failed to disclose any objects (with the possible exception of a 14th magnitude star near the Trifid nebula) with lower temperatures than those of stars already known. It would be a desirable investigation to apply the excellent infra-red sensitive plates developed within the past two or three years to a reasonably extensive search for cool "pre-giant"[3] stars. Until such an investigation discloses at least a few of the objects sought for we seem justified in believing that some physical cause sets a fairly definite lower limit to the effective temperature of tenuous stars of about zero absolute magnitude, and that the approach to this limit is marked by the instability of long-period variables. Cooler stars, if they exist, may re-

[2] *Pub. A. S. P.*, **39**, 198, 1927.

[3] So called when the current theory of stellar evolution made it appear that red giants represent the initial stage of stellar existence.

semble long-period variables at minimum, with absolute magnitudes not exceeding, say, +4.

On the Lockyer-Russell theory the interpretation of long-period variables would be as follows. Stars are formed by condensation of exceedingly tenuous dark matter perhaps in the form of finely divided dust particles. While the embryo star is taking shape, its outer portions, being cooler, remain murky after the nucleus has become incandescent. As the temperature of the nucleus and the intensity of its radiation increase, a stage will be reached at which the outlying dust clouds will be vaporized and their chemical compounds partly dissociated. The star will thus shine forth much more brilliantly than before. It may then cool again somewhat by radiating too rapidly for equilibrium, with a

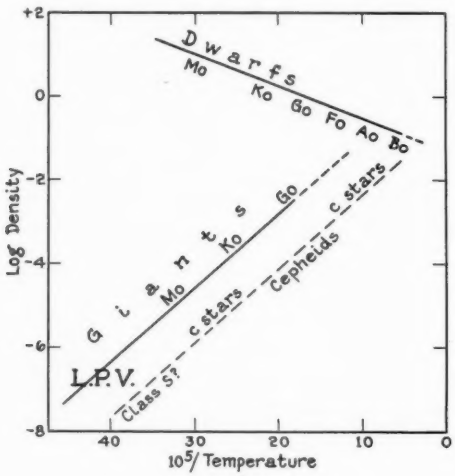

FIGURE 2

MEAN DENSITIES AND EFFECTIVE TEMPERATURES OF THE STARS
Reciprocal temperature is plotted against logarithm of the density.

consequent decrease in the intensity of emitted light. The decrease in brightness may be greatly accentuated by the re-formation of titanium oxide or other molecules that strongly absorb visual light; and a light surface veil of liquid or solid particles may possibly reappear. Such a process may occur many times in a cyclical fashion until the star is hot enough (and the outer portions drawn in close enough) to hold the materials of its outer envelope in a nearly transparent state. Until this comes to pass the object will be a red variable star. According to this notion a new long-period variable should occasionally appear in the sky if the process of star making is still going on. Objects with plenty of carbon and little oxygen will be of class N, the others mostly of class

M, but a few of exceptionally low density (possibly with an extra supply of zirconium) will be of class S.

Stellar variability seems to have some correlation with low density. Cepheid variables doubtless have lower densities than ordinary stars of corresponding spectral types, while long-period variables probably are more tenuous than any other stars. It will therefore be interesting to construct a diagram similar to Fig. 1 in which mean density instead of luminosity is plotted against effective temperature. Long-period variables will occupy the low density, low temperature corner (Fig. 2) while Cepheids and other "c" stars will fall in a region of lower density than do ordinary stars of classes B to K. Stars with spectra of class S have temperatures which overlap those of classes K and M, but probably have lower densities. Possibly they lie at the low temperature end of the c star sequence which parallels, at a lower density, the ordinary giant branch.

The discovery that two otherwise typical long-period variables, *o* Ceti and R Aquarii, have early-type companions with peculiar bright-line spectra raises the question whether these cases are casual and fortuitous, or whether they represent extreme examples of certain physical phenomena which occur in a less conspicuous form in all Me variables. A few other variables have combinations of spectral features which might be in line with the second alternative, but it would be rash to draw conclusions until a number of additional typical long-period variables have had their spectra carefully observed near minimum light.

Distribution

Concentration toward the Milky Way is characteristic of certain types of stars of high luminosity, for example O- and B-type stars and especially c stars, which include Cepheid variables. Long-period variables show much less preference for the galactic plane. Me stars are in fact scattered almost uniformly over the celestial sphere: the average latitude of 341 stars studied at Harvard[4] is 28°.4, the value for uniform distribution being 32°.7. Long-period variables of class S[5], as well as those of classes N and R[6], have average latitudes of about 19°, showing a somewhat higher allegiance to the Milky Way. The lower latitude may indicate higher absolute magnitudes, or less rapid space motion.

A very few long-period variables are known in globular clusters; none at all in open clusters. The meaning of these facts is not known, for the evolutionary relationships of clusters to the galactic system are most obscure. In spiral nebulae, now believed to be exterior galaxies or island universes, no typical long-period variables are known, but this fact does not prove their absence, for in these distant objects only those stars having the highest luminosities can be studied as individuals, and

[4] *Harvard Bulletin* 862.
[5] Popular Astronomy, **37**, 444, 1929, Table IV.
[6] *Ibid.*, Table V.

long-period variables of average brightness may be too faint to be detected. In the nearer spirals, however, the margin by which they are missed is small, if the data generally accepted are correct. If the limits of investigation of individual stars can be pushed down one or two magnitudes, long-period variables similar to those in our own system should become observable. It is to be hoped that such an extension will become possible in the near future.

Motions

One of the least tractable of the great problems of modern astrophysics is the explanation of the remarkable connections between the motions of the stars and their physical properties. A striking example of such a relationship lies in the high velocities of Me variables, particularly those having periods between 150 and 250 days. Curiously enough variables of classes S and N appear not to have extremely high mean velocities. For a brief account of observational facts concerning the motions of long-period variables the reader is referred to the fifth article in this series.[7] A recent important investigation by Dr. R. F. Sanford[8] of the radial velocities of N-type stars brings out the fact that the motions of long-period variables of type N do not differ materially from those of N-type stars in general. The motions of Me variables, on the other hand, differ greatly from those of non-variable M-type stars. Sanford's work shows that N-type variables take part in the general galactic rotation found from stars of other types.

An excellent statement of the general problem of stellar motions from a modern viewpoint may be found in a recent discussion by Dr. Gustaf Strömberg.[9] He attempts to account for the principal observational facts by tracing the development of our galaxy, as a typical spiral nebula, from a primordial gas. Connections between motion and physical characteristics are ascribed to differences in the original density of various galactic regions, and to the cumulative effects of viscous forces.

Conclusion

Long-period variables are doubtless trying hard to tell us important facts about stellar evolution. We hear them shouting but the words do not fit together into intelligible sentences. In the future we must try to be more skillful in interpreting their cries; or we may, in search of clues, listen more attentively to their fainter utterances; or finally, by more pointed questions, we may extract from them new and more helpful information.

The numerous problems of long-period variables appear at present to be divided into two groups; on the one hand those of individual stars, and on the other those concerning relationship to the stellar system.

[7] Popular Astronomy, **41**, 188, 1933.
[8] *Mt. Wilson Contr.*, No. 525; *Ap. J.*, **82**, 202, 1935.
[9] *Mt. Wilson Contr.*, No. 492; *Ap. J.*, **79**, 460, 1934.

Eventually problems of both groups will probably be seen as different aspects of one underlying interpretation. Increasing knowledge will tend to draw together and unify many diverse phases of present research. It is difficult to guess how near we are to a long step forward, but important ideas may come soon from any one of several quarters. The present difficulties are so interesting that we might almost regret to see them solved except for the pious hope and expectation that the solution will lead to problems still more fascinating.

CARNEGIE INSTITUTION OF WASHINGTON,
MOUNT WILSON OBSERVATORY, OCTOBER, 1935.

The Simpler Aspects of Celestial Mechanics

By HOMER A. HARVEY

AUTHOR'S FOREWORD

The purpose of this series of articles is to lay down a scientific, though simplified, foundation for real work by amateur astronomers, and for the comprehension of familiar phenomena in the sky. The movements of the heavenly bodies are beautiful in their precision, and, far from being the insolvable mystery that most people think, may be interpreted and predicted by the application of simple mathematical concepts. It is granted at the outset that the field of even simplified celestial mechanics is no playground for the amateur with no preparation in mathematics, and an adequate command of geometry and trigonometry is assumed. Given these prerequisites, however, his results will be close enough to afford satisfying illustrations of the principles involved. Further refinement requires the application of a multitude of minor corrections depending upon motions and forces so abstruse as to demand a grasp of mathematics far beyond the scope of this series. When it is borne in mind that the professional astronomers themselves have never yet been completely successful in defining the laws governing the motions of the moon, it will be readily understood that there are certain fields in astronomical mechanics which are closed for the amateur.

The series here offered presumes the amateur's desire to become something more than a mere star-gazer in the delightful realm of astronomy. He will need a few accessory tools—simple drawing instruments, a table of logarithms, a table of trigonometric functions, and most desirable, a slide-rule. The fact that the astronomer, accustomed as he is to working with instruments of high precision, will view with disdain the slide-rule in no wise disturbs my conviction that the results with its use are close enough to afford the keen pleasure of conquest which is the real goal of the seeker after truth for its own sake. Needless to add, the *sine qua non* of the amateur's equipment is an inquiring

mind and that quality of stubborn persistence which is the leading characteristic of the good finisher. He will never be overcrowded in a world already too full of good beginners.

The Horizon

The average person understands this term to mean the line of the landscape—hills, forests, plain—projected against the sky. This definition, however, is useful only in the most general way. For a person living upon a perfectly level plain, indeed, the definition of the horizon as given above might closely approximate the truth. But, for the inhabitant of a deep valley surrounded by jagged mountains, the horizon would be an irregular line lifted far toward the zenith, and entirely useless from a scientific point of view.

We will therefore construct a definition of this fundamental concept which will bear scientific scrutiny. Let us suppose the earth to be a perfect sphere. If, then, we set up at any point upon its surface a carpenter's level and sweep it about through a complete rotation it will trace out the true horizon of that station, not only upon the more elevated parts of the landscape, but upon the celestial sphere beyond, leaving out of consideration the effects of atmospheric refraction. We have now, incidentally, made our first important point, namely, that the horizon is a purely *local* phenomenon, and not a fixed configuration on the celestial sphere. Every spot upon the earth's surface has its own unique horizon, of which it is the center.

For the sake of visualizing the mechanism of the horizon, let us imagine ourselves in mid-ocean, immersed until our eye is at the level of the water. Our terrestrial horizon is now a circle of radius zero. In whatever direction we may turn, the surface of the water bends downward away from our line of vision, which is in a plane tangent to the surface and in contact with it only at the position of our eye.

Now let us raise ourselves above the water. We at once see about us a line of junction of ocean and sky—a perfect circle of which our eye is the center, and whose radius, constantly increasing as we rise above the water, bears a definite relationship to the height of our eye.

It now becomes evident that our horizon may be defined as the line of contact between the earth's surface and the conical surface whose apex is the observer's eye, and which is generated by sweeping about that tangent to the sphere which passes through his eye. Its altitude will be the vertical distance from the eye to the plane containing the circle of the horizon. The foot of the altitude will of course lie beneath the surface of the water an increasing distance as the eye rises and the size of the horizon increases, because the base of the cone is a plane, whereas the surface of the water curves upward toward the center from all points on the horizon.

If we could have taken with us our level to our station in mid-ocean and placed it at the original position of our eye, at the level of the water,

and swept it, as before, through a complete rotation, tracing its path upon the celestial sphere in red ink, let us say, we would thus have laid down the true horizon—again neglecting refraction. *These are the only conditions* under which our terrestrial horizon plane coincides with the true one outlined in red.

With our true celestial horizon fixed in this manner, let us now begin to rise above the surface of the water. We will notice immediately that our visible terrestrial horizon begins to sink below our red line, while remaining parallel to it, and continues to sink as we rise. As we rise at a uniform rate, at first it sinks rapidly, then gradually slackens its rate as we approach a point, thousands of miles out in space, from which practically the whole hemisphere of the earth would be visible. Actually, however, we could never reach so distant a point as to make the drop of the horizon reach a full 90°, thus causing it to vanish completely with the earth itself. In general, it is impossible to see a *full half* of any sphere from a single position, regardless of its distance. This fact will come out later when we examine the formula expressing the mathematical conditions.

This depression of the visible horizon below the true one due to elevation of the observer is called the *Dip*. Up to comparatively recent times man has been confined to relatively trivial altitudes, and hence to narrow horizons and small dips. Now that he has attained almost 14 miles in a balloon, he has been able to sweep comparatively enormous areas of the earth's surface in a single glance. It will be interesting to examine the law governing this relationship.

The Dip of the Horizon

The true horizon divides the apparently hollow sphere of the sky surrounding the earth into halves. The stars upon the celestial sphere are at virtually infinite distances from us, so that if we pass a horizontal plane through the eye of the observer and another plane parallel to it through the center of the earth, and continue them outward infinitely in all directions, they will meet in *one and the same circle* upon the celestial sphere, namely, the true horizon for that observer, and a star lying upon this line has for him an altitude of zero.

Study Figure 1 carefully. It illustrates one of the most important concepts in astronomy, and one of the most frequently misconceived. The reason for this is obvious. Geometrical figures involving infinite distances can never be drawn to scale, and are hence bound to be misleading, especially to the visually minded student. Here is the important point. In Figure 1, the parallel lines, representing the edge-views of the planes mentioned, although separated by the distance $R + h$, some 4000 miles, would, if produced outward to the celestial sphere, meet upon it in the *same* point *s*, and not in two points *s* and *s'*. Thus we see that exactly half the celestial sphere will lie above the planes of *both* *x* and *y*. But we also see that from the elevation h the terrestrial hori-

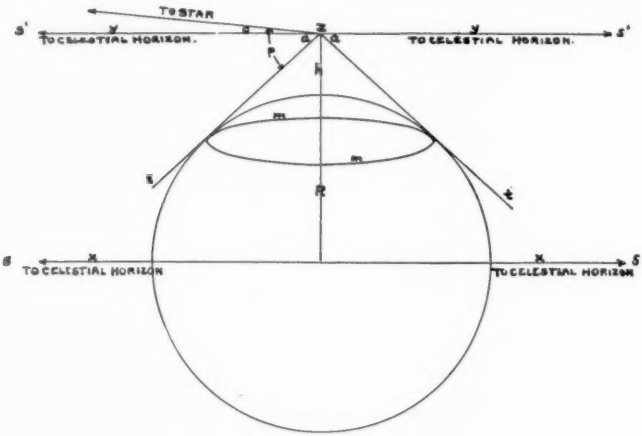

FIGURE 1
p, observed altitude of star; o, corrected altitude; z, observer; mm, observer's horizon; a, dip.

zon lies in the direction t from the observer, at an angle of a below the direction of the true horizon, y. This angle a is the *dip*, and must be taken into account when measuring the altitude of celestial objects above the true horizon. Let us examine its mathematical relationships, along with those of its related quantity, the distance of the visible horizon.

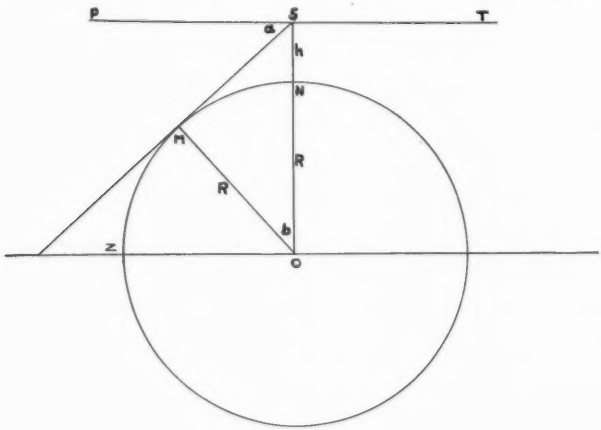

FIGURE 2
a, dip; PT, direction of true horizon; b, central angle subtended by MN, observer's horizon distance.

To simplify our calculaions, let us assume

Radius of earth = 4000 mi.
Circumference = 25000 mi.

In the figure, $\angle a = \angle b$ (sides perp., right to right, and left to left).
In triangle OMS, a right-angled triangle (M point of tangency)

$$\begin{aligned}(MS)^2 &= (OS)^2 - (OM)^2 \\ &= (R+h)^2 - R^2 \\ &= R^2 + 2Rh + h^2 - R^2 \\ &= 2Rh + h^2\end{aligned}$$

$$\text{Therefore } MS = \sqrt{h(2R+h)}$$

$$\begin{aligned}\text{Now tang } b &= MS/R \\ &= \sqrt{h(2R+h)}\,/\,R \\ &= \sqrt{h(8000+h)}\,/\,4000,\end{aligned}$$

where h is expressed in miles.

Therefore $\angle b\ (= \angle a\ \text{Dip}) = \tan^{-1}\sqrt{h(8000+h)}\,/\,4000^*$ (Formula 1)

And, since $\angle a = \angle b$,
Horizon Distance (in miles) = $(a/360 \times 25000$ = Dip (in degrees) $\times$ 69.4 (Formula 2)

Horizon Distance will be understood as meaning the radius of the visible horizon as measured along the *surface of the earth.*

EXAMPLE 1

What is the dip of the horizon from a height of 2 miles?
How far can one see on the earth's surface from that height?

$$\text{Dip} = \tan^{-1}\sqrt{2(8000+2)}\,/\,4000$$
$$\text{Tang dip} = .03165$$
$$\text{Dip} = 1^\circ\ 49'\ \text{approx.}\ (= 1°.82)$$
$$\text{Distance to Horizon} = 1.82 \times 69.4 = 126.4\ \text{mi}$$

EXAMPLE 2

What is the dip and distance to horizon for a height of 36 feet?

$$\text{Tang Dip} = \sqrt{(36/5280)(8000+36/5280)}\,/\,4000$$
$$.001845$$
$$\text{Dip} = 6'\ \text{approx.}$$
$$\text{Distance to horizon} = (6/60) \times 69.4 = 6.94\ \text{mi.}$$

It will be seen upon examination of the formula for the dip that however large a value we may assign to h, the value of the numerator can never reach infinity. Hence the value of the fraction can likewise never reach infinity, and the angle whose tangent it represents can never reach 90°. By reference to Figure 2 it is apparent that for M to reach Z, thus enabling an observer at S to see the whole hemisphere, *a*, the dip, would have to equal 90°. Since we have proved that this can never occur, we conclude that we can never see the whole hemisphere at once, however far we may recede from it.

It will be interesting to examine the reason for the fact that the height

*$\text{Tan}^{-1}\,k$ = "Angle whose tangent is *k*."

of the observer increases at a more rapid rate than the distance of his horizon. Let us choose two widely separated heights, with their corresponding horizon distances, in order to bring out the discrepancy more plainly. A height of 36 feet yields a horizon distance of 6.94 miles, as seen. A height of ten miles corresponds to a horizon distance of 281.2 miles. Thus, in order to increase our horizon distance 41 times we have had to increase our height 1465 times.

The horizon distance varies directly as the dip; that is, if the dip be trebled, let us say, the horizon distance will also be trebled. This will be seen on examining the formula

$$\text{Hor. Dist.} = \text{Dip} \times 69.4 \text{ mi.}$$

This means simply that whatever amount we substitute for the dip, the horizon distance will be 69.4 times that amount, a fixed ratio. But when we examine the relationship between the dip and the height, we find quite another picture.

$$\text{Dip} = \tan^{-1} \sqrt{h(8000 + h)} \,/\, 4000$$

In th first place, the formula involves the *square root* of h. This does not increase in the same arithmetical ratio as the number itself. For example, the square root of 9 is 3, but the square root of 18 is not 6. But the real discrepancy lies in the fact that the tangent increases much more rapidly than the angle, and this discrepancy increases with the size of the angle. For example, the tangent of 35° is .70021; that of 70°, an angle *twice as great*, is 2.7475, nearly *four* times as great.

The result is, that if we are to increase the dip, and hence the distance of the horizon, we must increase the tangent, and hecne the value of h, relatively very rapidly. This does not come out so well for small values of the height and dip, but the disproportion becomes increasingly greater for large angles. To illustrate this fact, let us assume a very large horizon distance, say London to New York, 3000 miles, and compute the distance one would need to be above London to see New York.

Working our formula backward:

$$\text{Angle at center, } b = 3000 \times 360° \,/\, 25000$$
$$b = 43° \, 12', \text{ nearly.}$$

$$\text{But } \tan b = \sqrt{h(8000 + h)} \,/\, 4000$$

$$.93906 = \sqrt{h(8000 + h)} \,/\, 4000$$

Clearing the fraction and squaring both sides,

$$h^2 + 8000h = 14{,}100{,}000$$

Solving the quadratic for h,

$$h = 1488 \text{ mi.}$$

Thus, for horizon distances of this general magnitude, we would have to be about half as far above the earth, as compared with 1/60 as far for distances as small as 126 miles, as shown. It may be easily computed

that in order that the horizon distance shall be *equal* to the height we would have to recede 4175 miles from the earth.

These fantastic examples, if they do nothing more, serve to impress upon our mind the mechanics of a globe in space, and enable us to project ourselves in imagination outward with a definite idea of what we might expect to see. Better yet, they serve to remind us forcibly that when the captain of a vessel climbs up to the bridge to make his observations he has inaugurated the same process of depressing his horizon. In this case it is a matter of 5 or 6 minutes of arc, an amount scarcely observable with the unaided eye, but this time of prime practical importance, since the neglect of it in making his subsequent calculations for his position would introduce an error of about 4 miles in the latitude of the ship-lanes of the North Atlantic.

Nothing has been said purposely about the correction of altitudes for atmospheric refraction, as clearness demands that the problem thus far be kept one of simple mathematics. However, it is an easy matter to apply the proper correction from tables in texts on Navigation, which give figures for any altitude above the horizon. The effect of refraction will be to increase slightly the distance of the visible horizon or to increase the apparent elevation of a celestial object above it, according to which end of the line of sight the observer considers himself to occupy.

Two simplified formulae are in common use among navigators for approximating the dip and horizon distance.

1. Dip (in minutes) $= \sqrt{\text{Elevation}}$ (in feet).
2. Distance of horizon (in miles) $= 1.32\ \sqrt{\text{Elevation}}$ (in feet).

The latter formula is corrected for refraction, and we may make use of it in solving the following problem:

On the occasion of the recent stratosphere flight, the balloon reached a height of 13.7 miles. How large a circle of the earth's surface were the occupants able to see?

$$\begin{aligned}\text{Distance horizon} &= 1.32\ \sqrt{72336} \\ &= 1.32 \times 269 \\ &= 355 \text{ mi.}\end{aligned}$$

Therefore there was visible from that height a circle of territory 710 miles in diameter, enough to have included the combined areas of North and South Dakota, Montana, and Wyoming.

We have chosen to elaborate the rational mathematical calculation of these formulae, since it shows the true relations of the problem. Short-cuts are useful in practice, but are poor teachers. None but "practicals" and experts can afford to use them.

A final practical example:

How far can a light atop a lighthouse 100 feet high be seen from the deck of a vessel 28 feet above the water?

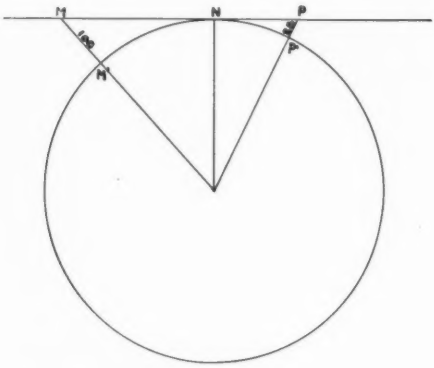

FIGURE 3

MM′, lighthouse; PP′, ship.

$$MN = 1.32\sqrt{100} = 13.2 \text{ mi.}$$

$$NP = 1.32\sqrt{28} = 6.99 \text{ mi.}$$

Adding, 20.19 mi.

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An Angle Connected with the Mean Place in the Ellipse

By W. C. BRENKE

To determine the true position in an elliptic orbit we pass from M to E and from E to v by means of the equations

$$(1) \qquad M = E - e \sin E,$$

$$(2) \qquad \tan \tfrac{1}{2} v = \tan \tfrac{1}{2} E \sqrt{(1+e)} / \sqrt{(1-e)}.$$

If the eccentricity is not quite small the first step requires several successive approximations to obtain a sufficiently accurate solution of Kepler's equation.

If now we lay off the mean anomaly M from the empty focus, and if the orbit is of moderate eccentricity, say $e<.25$, we arrive at once at a point in the orbit very close to the true position; within one degree for the planetary orbits. Let θ be the true anomaly of the point so determined. In Figure 1, F′ is the empty focus, angle $AF'P = M$, angle $AFP = \theta$, and $FP = r$. Then triangle FPF′ gives

$$(3) \qquad r/2ae = \sin M / \sin (\theta - M).$$

The equation of the ellipse gives

$$(4) \qquad r = a(1-e^2) / (1 + e \cos \theta).$$

From (3) and (4) we obtain

$$2e \sin M / \sin(\theta - M) = (1-e^2) / (1+e\cos\theta),$$

or,

$$2e \tan M / (\tan\theta - \tan M) = (1-e^2) / (\sec\theta + e).$$

Replacing the functions here involved by their values in terms of the tangents of the half angles and reducing, we find the simple formula

$$(5) \qquad \tan \tfrac{1}{2}\theta = (1+e)\tan \tfrac{1}{2}M / (1-e).$$

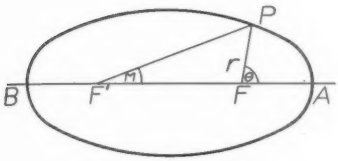

Fig. 1

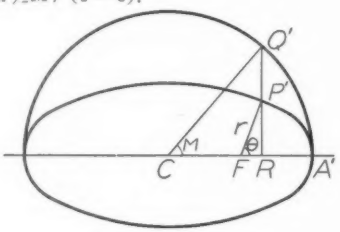

Fig. 2

This relation bears a curious resemblance to (2) which we may make complete by assuming a fictitious eccentricity ϵ such that

$$(6) \qquad (1+e) / (1-e) = \sqrt{(1+\epsilon)} / \sqrt{(1-\epsilon)},$$

or,

$$\epsilon = 2e / (1+e^2).$$

It appears further that if we draw a second ellipse with the same foci F and F′, and eccentricity ϵ, its semi-major axis will be determined by $a'\epsilon = ae$, and that, if θ, M, M′ denote respectively the true, eccentric, and mean anomalies in this ellipse, every equation involving a, e, v, E, M valid for the first ellipse can be changed into a correct equation for the new ellipse by substituting a′, ϵ, θ, M, M′ respectively for a, e, v, E, M and conversely. This follows readily if we can show that when we lay off θ as the true anomaly and M as the eccentric anomaly in the new ellipse the points P′ and Q′ lie on the same perpendicular to the major axis. Regarding R as the projection of Q′ on A′C we have

$$CR = CQ' \cos M = a' \cos M.$$

Regarding R as the projection of P′ on A′C we have

$$CR = ae + FP' \cos\theta.$$

Equating these values of CR and replacing FP′ by its value from the equation of the ellipse we find

$$a' \cos M = ae + a'(1-\epsilon^2)\cos\theta / (1+\epsilon\cos\theta),$$

or,

$$\cos M = (\epsilon + \cos\theta) / (1+\epsilon\cos\theta),$$

or,

$$\tan \tfrac{1}{2}\theta = \tan \tfrac{1}{2}M \sqrt{(1+\epsilon)} / \sqrt{(1-\epsilon)}.$$

This establishes the correspondence of the two sets of five quantities as indicated above.

Developments in series show that the differences E — M, v — M, v — E are all of the first order in e; thus

(7) $v - M = 2e \sin M + 5/4\, e^2 \sin 2M + 1/12\, e^3 (13 \sin 3M - 3 \sin M) + \ldots$

Now the equation $\tan y = k \tan x$ gives rise to the series

$$y - x = [(k-1)/(k+1)] \sin 2x + \tfrac{1}{2}[(k-1)^2/(k+1)^2] \sin 4x + \tfrac{1}{3}[(k-1)^3/(k+1)^3] \sin 6x + \ldots$$

Applying this to (5) with

$$k = (1+e)/(1-e) \text{ or } (k-1)/(k+1) = e, \text{ we have}$$

(8) $\theta - M = 2(e \sin M + \tfrac{1}{2}e^2 \sin 2M + \tfrac{1}{3}e^3 \sin 3M + \ldots)$

Then (7) — (8) gives

(9) $v - \theta = \tfrac{1}{4}e^2 \sin 2M + 1/12 e^3 (5 \sin 3M - 3 \sin M) + \ldots$

This is of the order of e^2, which explains the close agreement of v and θ for small eccentricities.

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On the Classification of Novae

By B. P. GERASIMOVIC

The number of known galactic and extragalactic Novae seems to be large enough to warrant the first attempt at their rational classification. It is true that sufficient photometric or spectroscopic data are available for not more than fifteen brighter Novae, our information on fainter objects being rather incomplete. However, paying due attention to this critical remark, we cannot help thinking that the bulk of these data is not smaller than that on which the first general classification of variable stars was based (E. C. Pickering, 1880). On the other hand even an incomplete but essentially correct classification of Novae should be of use for further investigations of these phenomena.

In this paper we are dealing only with "normal" Novae, to which probably belong all the known galactic Novae and those extragalactic objects whose brightness at maximum is considerably lower than that of the parent galaxy.

Light curves of common variable stars are known to be of limited physical significance. The most important features of light variations of red variables probably represent only an exaggerated and distorted image of small variations in molecular content, the most important part of the spectrum being far from the region covered by visual or photographic data. The light curves of Cepheids are of course much more significant, though even in these cases color curves are of higher importance, as reproducing temperature variations.

So far as our present information on Novae goes, we have good reasons to think that their light curves are more significant than those in any other class of variables. In fact, the temperature changes near the maximum being relatively small, almost the whole light variation of a

Nova in its earlier stages seems to be produced by the change in effective radius. This induces us to consider the light curves of Novae as the most important records of their outbursts, which will be of lasting value, however detailed and far reaching our spectroscopic information on these phenomena may be. On the other hand, although recognizing the spectroscopic peculiarities of various Novae, we, nevertheless, notice that their spectroscopic development is more or less the same, with the exception of the differences in final stages; their spectra differ mostly in the size of displacements and the rate of progressive changes, which remain the same both for spectroscopic and photometric features. On the contrary, there are large differences in light curves of Novae which, being of greatest physical significance, are intimately connected with their life careers and the speed of their developments. Therefore the classification of light curves of Novae is nothing else than the empirical classification of the types of Nova outbursts.

At the outset in such an investigation, one immediately meets a difficulty which is inherent in every work of classification. The problem consists in finding the most important features of light variation, which are easily observable and are at the same time of the highest physical significance, however difficult the interpretation of them may appear. We have no reason to think that the variety of Novae is a one-dimensional assembly in most details. Indeed, it would be rather surprising if such complicated phenomena could be arranged in a simple linear array. However, there is no possibility of starting classificational work in two dimensions. Remembering the history of early astrophysics, we can first aim only at a linear classification, being fully aware of its preliminary character.

The following major features of the light curves of Novae should be first considered:

(1) Steepness in rise.
(2) Rate of decrease in brightness.
(3) Type of maximum.
(4) Range.
(5) Secondary almost periodic oscillations.
(6) Secondary prolonged brightening near the minimum.

The range (4) does not represent a good classificational criterion, such dissimilar Novae as Aquilae 1918 and Pictoris 1925, or Ophiuchi 1848 and Ophiuchi 1933 having the same ranges. The steepness in rise (1), which certainly is one of the most important guiding features, unfortunately cannot be of use, simply because in most cases the rise of a Nova remains unobserved.

The most important and practical classificational criteria are the type of maximum and the rate of decrease in brightness, which are strongly interrelated. Secondary prolonged brightening (Novae Aurigae 1892 and Coronae 1866) gives an important additional datum characterizing the behavior of a Nova near its minimum. Secondary almost periodic

oscillations (5) in the descending branch, notwithstanding their probable theoretical importance, are from the classificational point of view not so significant as features (2) and (3).

The obvious phenomenon of a Nova, whatever its causes are, consists in a temporary brightening of the star, connected with the ejection of matter, which is spectroscopically represented by the well-known displaced absorption and undisplaced emission lines. As a certain qualitative measure of the "intensity" of Nova phenomenon we can take the integrated light curve (properly reduced to bolometric magnitudes), which can be considered as representing the amount of energy set free during the outburst. This point of view brings us to the combined application of the criteria (2), (3), and (6), paying due attention of course to the criterion (4). Accordingly such a spectacularly flashing Nova as Aquilae 1918 should be classed one or two steps farther than say, Pictoris 1925 or Anthelm's Nova 1670, which, having the same range, showed a much slower decline in brightness. Again assuming that the ranges of such permanent Novae as P Cygni or semipermanent ones such as η Carinae are sufficiently large, we should consider them as the Novae of higher degree than, say, Pictoris 1925 (even taking into account their rather low velocities of outflow). This point of view of course does not imply that the mass ejected during the outburst of, say, Nova Pictoris 1925 is larger than that corresponding to the outburst of Nova Aquilae 1918.[1]

We subdivide all "normal" Novae into two major classes, (I) slow Novae and (II) flashing Novae, both classes comprising minor subclasses.

The proposed arrangement runs as follows:

I. *Slow Novae,* showing protracted and wavy maxima.

Ia. *Permanent Novae,* which do not show any marked fluctuations in light or in spectrum and seemingly represent steady non-static configurations (P Cygni).

Ib. *Semipermanent Novae,* which exhibit systematic changes and fluctuations both in light and in spectrum (η Carinae).

Ic. *Slow Novae proper* showing protracted maximum or a wavy series of maxima, followed by a gradual decline toward minimum (Nova Pictoris 1925, Ophiuchi 1848).

Id. *Slow Novae with a sudden fall toward minimum.* The same as Ic with a sudden decrease in brightness, which follows a rather protracted maximum. There are only two strikingly similar representatives of this group (Nova Aurigae 1892, Herculis 1935). The first of these showed prolonged brightening (by 5^M) after a sudden fall; in this re-

[1] Guarding the purity of the classificational principle we shall not take into account the type of final spectrum, though the outbursts of Nova Coronae 1866 (Sp. M) and Geminorum 1912 (Sp. WR), for example, may have been provoked by quite different causes. This should be taken into account in future two-dimensional classifications.

spect the future behavior of Nova Herculis is of much interest.

II. *Flashing Novae,* exhibiting very sharp "pointed" maximum with subsequent rapid decline.

IIa. *Flashing Novae proper* (Nova Aquilae 1918). Some representatives of this group show faster changes and some show slower. The fastest is Nova Cygni 1920 and the slowest, Geminorum 1912. Additional data may require a further subdivision of this group.

IIb. *Flashing Novae exhibiting very rapid fall with subsequent partial recovery.* Nova Coronae 1866 is the only Nova of this kind so far known.

The following table contains the data on all brighter galactic Novae, which can be classified with some certainty; of course it does not pretend to be complete.

	Galactic latitude	Range	Change in magn. during 1st 100 days	Secondary oscillation	Secondary brightening near minimum	Present state
I *Slow Novae*						
Ia P Cygni	0°					
Ib η Carinae	0					
Ic Vulpeculae 1670	0	12^M	2^M			
Ophiuchi 1848	+15	7.7	<2	present		Variable
Ophiuchi 1919	+12	>9	about 2			
Aquilae 1925	−13	>7	very small			
Pictoris 1925	−25	11.6	2.4			
Id Aurigae 1892	0	10.2	9.0[2]		present (5^M)	No variation
Herculis 1935	+25	12.2	6.8			
II *Flashing Novae*						
IIa Cygni (Q) 1876	− 8	12	5.5			Variable
Persei 1901	− 9	13.5	6.0	present		Variable
T Pyxidis 1890	+10	6.0				
Lacertae 1910	− 4	>9	5			No variation
Geminorum 1912	+16	11	4.1	present		No variation
Aquilae 1918	− 1	11.7	6.1	present		No variation
Cygni 1920	+12	12.6	7.5			No variation
RS Ophiuchi 1933	+ 8	6.8	6.8			
IIb Coronae (T) 1866	+46	8	6.0	present	present (2^M)	No variation

Since from a classificational point of view it does not matter how many times a given star may have undergone a Nova outburst, our list contains also such recurrent Novae as T Pyxidis and RS Ophiuchi. In fact there is nothing in the spectrum and light curve of RS Ophiuchi during its latest outburst which could preclude its being classified as a true flashing Nova. Of course this classification refers to a given outburst and we have no guarantee that future outbursts of this Nova will not be of type I.

[2] This item in the Id group does not adequately characterize the rate of decline. *E.g.,* in Nova Aurigae 1892 it was 1^M for first 60 days after the maximum and then it changed by 8^M in the course of 35 days.

The examination of our table, as well as of incomplete data on other Novae, shows that there is no marked preponderance in our galaxy of one or the other type of Novae. Both types I and II are also well represented in Messier 31, some of them (Nos. 26, 36, 39 in Hubble's Catalogue), which have been visible in the course of several years, probably belonging to Ia and Ib subtypes. On the other hand, quite remarkably, there is only one II-type Nova known in the Large Magellanic Cloud (Luyten's Nova), this galaxy strongly preferring Ia subtype.

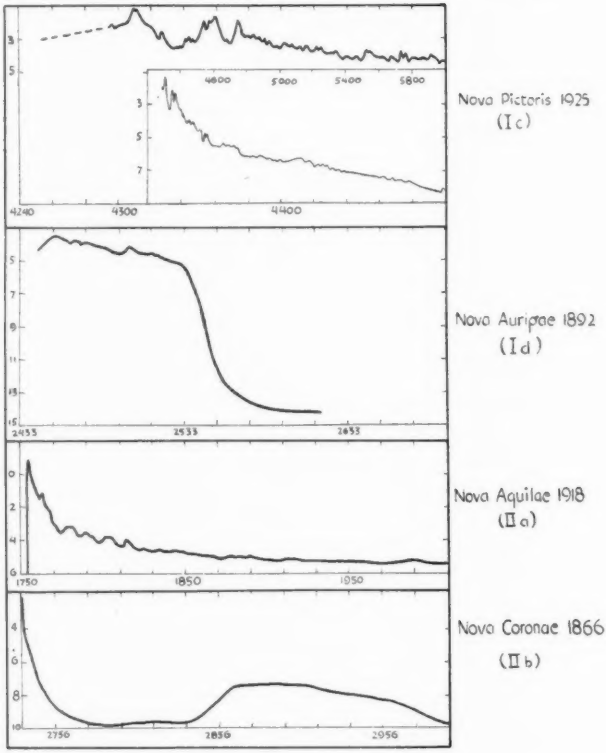


FIGURE 1.

LIGHT CURVES OF TYPICAL NOVAE, REDUCED TO THE SAME SCALE.

The distribution in galactic latitude and magnitude at maximum does not reveal any marked systematic difference in luminosity between the two types of Novae. This seems to be in agreement with the behavior of Novae in Messier 31. Further examination of existing data does not show any difference between the two types as to the occurrence of secondary oscillations and of the persistent variability in the post-outburst

stage. Besides, there is no essential spectroscopic difference between the two types. The displacements of absorption lines soon after the maximum seem to be smaller in the Ia, Ib, and Ic groups (100-330 km), but are larger in Id Novae (Nova Aurigae v = 840 km). In II-type Novae these velocities range from 540 km (Geminorum 1912) to 1600 km (Persei 1901).

We have become accustomed to consider spectacularly flashing Novae as the only true representatives of this class and we call "exceptional" such Novae as Pictoris 1925 or Herculis 1935. This point of view is hardly correct. Slow Novae are quite normal objects amply represented in our Galaxy.

In a discussion of the classification of Novae it is difficult to avoid mentioning so-called "Novae-like variables." This group seems to be far from uniform, being of a rather mixed character. Its components are as follows:

(1) Recurrent Novae like RS Ophiuchi.

(2) η Carinae-like variables.

(3) Irregular variables showing M-type spectrum with superposed nebular emission. These stars do not differ much from Nova Coronae 1866 in its post-outburst stage.

(4) Small range irregular variables, showing variation of R Coronae kind and nova-like spectra.

(5) U Geminorum (or SS Cygni) variables.

Only objects (4) and (5) do not fit our classificational scheme. These enigmatic variables, in some way affiliated with Novae, probably represent a special group and seem to be of lower luminosity. The relatively low luminosity of U Geminorum variables is proved by statistical considerations[3] and by proper motion data, however crude and limited they are.[4] These variables can be properly called *Sub-Novae,* group (4) being analogous to I-type Novae and (5) to flashing Novae of II-type.

These sub-Novae should not be confused with Lundmark's "dwarf Novae." According to Lundmark[5] the existence of dwarf Novae is shown by a number of faint Novae around the Northern Milky Way pole. As a matter of fact there are[6] four suspected Novae in galactic latitudes higher than 60°, probably none of them being a real Nova. Two objects (U Leonis, X Virginis) are common variables, the data on the other two (RZ Leonis and N Comae Berenices 1877) being extremely meagre.

Poulkovo, U.S.S.R., May, 1935.

[3] Gerasimovič, *A.N.*, **251**, 255, 1934.
[4] Parenago and Kukarkin, *Veränderliche Sterne,* **4**, 249, 1934.
[5] Lundmark, *Upsala Medd.*, **30**, 60, 1927, and *Lund. Medd.*, **74**, 2, 1935.
[6] Stratton, *Hndb. d. Aph.* VI, 254.

Section D (Astronomy) of the A.A.A.S. at St. Louis, Missouri

By JESSICA YOUNG STEPHENS

The annual meeting of Section D (Astronomy) of the American Association for the Advancement of Science was held at St. Louis, Missouri, from Monday evening, December 30, 1935, to Wednesday afternoon, January 1, 1936. The officers for the meeting were as follows:

Vice-President and Chairman, H. R. Morgan, U. S. Naval Observatory, Washington, D. C.

Retiring Vice-President, Frederick Slocum, Wesleyan Observatory, Middletown, Connecticut.

Secretary, H. T. Stetson, Harvard University, Cambridge, Massachusetts.

Section Committee: H. R. Morgan, Chairman; H. T. Stetson, Secretary; Dinsmore Alter, University of Kansas, Lawrence, Kan.; Raymond Smith Dugan, Princeton University Observatory, Princeton, N. J.; C. O. Lampland, Lowell Observatory, Flagstaff, Arizona; W. H. Wright, Lick Observatory, Mt. Hamilton, Calif.; E. S. Haynes (delegate from the American Astronomical Society and from the Astronomical Society of the Pacific), University of Missouri Observatory, Columbia, Mo.; W. J. Luyten (delegate from the American Astronomical Society), University of Minnesota Observatory, Minneapolis, Minn.; S. A. Mitchell (delegate from the American Association of University Professors), Leander McCormick Observatory, Charlottesville, Va.

The meeting opened Monday evening with the General Session of the Association which was held at the Municipal Auditorium. The president of the Association, Dr. Karl T. Compton, presided. Professor E. L. Thorndike of Columbia University gave the retiring vice-presidential address on "Science and Values." This was followed by a reception tendered to the Association and guests by the St. Louis local committee.

About forty members attended the Section D meetings. Vice-President Morgan presided at all separate and joint meetings of the section and Dr. Stetson served as secretary. The Tuesday meetings were held at Washington University. The morning session was devoted to the presentation and discussion of short papers. The afternoon meeting was held jointly with the American Meteorological Society. About one hundred were present at this meeting. Invited papers of interest to both astronomers and meteorologists were presented by R. H. Goddard of Clark University, C. G. Abbot of the Smithsonian Institution, H. W. Clough of Arcade, New York, H. T. Stetson of Harvard University, and Watson Davis of Science Service, Washington, D. C. These papers dealt with solar variation and correlated terrestrial phenomena, the broadcasting of cosmic data, and the development of rockets for the purpose of carrying recording apparatus into the upper atmosphere.

A general session of the Association followed the afternoon meeting.

Dr. Frederick Slocum, the retiring vice-president, gave a very interesting illustrated lecture on "The Changing Picture of the Universe," in which he traced the development of ideas about the structure of the universe from the earliest times to the present.

The Wednesday morning session for the presentation and discussion of short papers was held at the School of Commerce and Finance of St. Louis University.

At noon the members took a bus to the home of Mr. and Mrs. Eugene Stephens in Brentwood where a buffet luncheon was served and the meetings were brought to a close.

Some of the very interesting things brought out in the shorter papers were as follows:

In his paper on meteors Dr. Wylie estimated that the number of naked-eye meteors reaching the earth daily is 24 million and the number of telescopic meteors is millions of millions. He calculated that an inch of meteoric material has been deposited on the earth since its origin.

Dr. Arend showed an interesting application of affine geometry and the method of least squares to the determination of parallaxes.

Messrs, Stebbins and Whitford gave the results of measurements of atmospheric disturbances by means of the photo-electric cell and suggested the possibility of using the cell for the purpose of selecting the location of new observatories.

In his talk on the ultra-violet spectrum of Arcturus, R. W. Shaw suggested that in general the ultra-violet spectrum be divided into three divisions,—"near" from 3968 to 3650 A, "far" from 3650 to 2950, "extreme" below 2950 A.

Dr. Fath pointed out that a comparison of the light curve and the velocity curve of Delta Scuti seemed to indicate that the star is a pulsating star.

Dr. Slipher's paper on Mars contained a detailed study of bright clouds on Mars. He concluded that they are water vapor rather than dust clouds and that the atmosphere of Mars is more earthlike than that of any other planet.

Particularly outstanding among the short papers was the one by E. F. Carpenter in which he showed evidence of tidal action between extragalactic nebulae. He showed pictures of filaments of material connecting two galaxies and suggested that the two nebulae might have passed one another and produced mutual tides. He gave a criterion for classifying pairs of galaxies as "optically double" and "physically double," the later being those in which the distance between centers is less than or equal to the diameters of the nebulae. He showed that there is evidence of tidal action in all physical doubles studied. Another striking thing brought out was that the arms seem to be at right angles to the edges of the nebulae.

At the meetings of the council of the Association Dr. F. H. Seares of the Mt. Wilson Observatory was elected vice-president of section D for

the year 1936 and Dr. J. C. Duncan of the Whitin Observatory, Wellesley, Massachusetts, was elected a member of the section committee to succeed Dr. W. H. Wright whose term expired.

In connection with the meetings section D sponsored an astronomical exhibit at the Municipal Auditorium. It consisted of photographs and transparencies from the large observatories of the United States and Canada, examples of aluminized mirrors made by amateurs and professionals, and examples of work of the American Association of Variable Star Observers and of the work of amateurs. A particular attraction was a complete working model of the new McDonald Observatory and its 82-inch telescope loaned by the Warner and Swasey Company of Cleveland.

Planet Notes for March, 1936

By CLIFFORD E. SMITH

Note: All times, unless otherwise stated, are Central Standard Time.

The *Sun* will be moving with an apparent northeasterly motion from the central part of Aquarius to the central part of Pisces. On March 20 at $12^h\ 58^m$ P.M., the sun will be at the Vernal Equinox, and this event will officially mark the beginning of spring. At the beginning of the month, the distance from the earth to the sun will be about 92.1 million miles, and this distance will increase about 0.76 million miles during the month. The position of the sun on the first and last days of the month will be, respectively: R.A. $22^h\ 47^m$, Decl. $-7°\ 44'$, and R.A. $0^h\ 37^m$, Decl. $+4°\ 0'$.

The phenomena of the *Moon* will occur as follows:

Full Moon	March 7 at	11 P.M.
Last Quarter	16 "	3 A.M.
New Moon	22 "	10 P.M.
First Quarter	29 "	3 P.M.
Apogee	9 "	10 P.M.
Perigee	23 "	3 A.M.

Mercury will be a morning object and during the first few days it will rise about an hour and a half before the sun. During the month it will move in an easterly direction from the central part of Capricornus across Aquarius to the central part of Pisces. Its distance from the earth will increase from about 94 to about 123 million miles. The corresponding change in apparent diameter will be from about 7 to 5 seconds of arc. Conjunction with the moon will occur on March 21 at 10:00 P.M. (Mercury 7°.5 S). On March 22 at 11:00 A.M. there will be a conjunction with Saturn (Mercury 36′ S). The position of Mercury on the first and last days of the month will be as follows: R.A. $21^h\ 5^m$, Decl. $-17°\ 23'$, and R.A. $0^h\ 2^m$, Decl. $-2°\ 0'$.

Venus will be a morning object, rising about two hours before the sun, and moving with an apparent easterly motion from the central part of Capricornus to the eastern part of Aquarius. Its distance from the earth on March 1 will be about 127 million miles and this distance will increase about 15 million miles during the month. The corresponding change in apparent diameter will be from about 12 to 11 seconds of arc. Conjunction with the moon will occur on March 21 at 6:00 A.M.

(Venus 5°.8 S). On March 30 at 3:00 P.M. there will be a conjunction with Saturn (Venus 26′ N).

Mars will be an evening object during the month but it will be too near the sun in apparent position to be of much interest. It will move with an apparent easterly motion from western to eastern Pisces. Its distance from the earth will be about 200 million miles and its apparent diameter will be about 4 seconds of arc. Conjunction with the moon will occur on March 24 at 11:00 A.M. (Mars 5°.4 S).

Jupiter will be a morning object moving with an apparent easterly motion in southern Ophiuchus. During this period it will rise about midnight since quadrature west of the sun will occur on March 13 at 6:00 P.M. Its distance from the earth will be about 485 million miles and its apparent diameter about 35 seconds of arc. Its position at the middle of the month will be R.A. $17^h\,31^m$, Decl. −22° 40′. Conjunction with the moon will occur on March 15 at 11:00 P.M. (Jupiter 2°.0 N).

Saturn will continue in Aquarius but it will be too near the sun in apparent position to be of interest since conjunction with the sun will occur on March 3 at 7:00 A.M. Conjunction with the moon will occur on March 21 at 11:00 P.M. (Saturn 7°.0 S). On March 22 at 11:00 A.M. there will be a conjunction with Mercury (Saturn 36′ N). A conjunction with Venus will occur on March 30 at 3:00 P.M. (Venus 26′ S).

Uranus will be an evening object moving with an apparent easterly motion in western Aries. During the middle of the month it will set about two and a half hours after the sun. Its distance from the earth will be about 1900 million miles and its apparent diameter will be about 3.3 seconds of arc. On March 25 at 2:00 A.M. there will be a conjunction with the moon (Uranus 5°.2 S). Its position on the 15th of the month will be R.A. $2^h\,5^m$, Decl. +12° 9′.

Neptune will be a night object in southeastern Leo. It will be above the horizon most of the night hours since opposition will occur on March 5 at 9:00 P.M. Its apparent motion among the stars will be retrograde. The distance of Neptune from the earth will be about 2700 million miles, and its apparent diameter will be about 2.5 seconds of arc. Conjunction with the moon will occur at midnight on March 7 (Neptune 6°.2 N). Its position on March 15 will be, R.A. $11^h\,7^m$, Decl. +6° 48′.

OCCULTATION PREDICTIONS

(Taken from the *American Ephemeris.*)

OCCULTATIONS VISIBLE IN LONGITUDE +72° 30′, LATITUDE +42° 30′.

Date 1936		Star	Mag.	IMMERSION Greenwich C.T. h m	IMMERSION a m	IMMERSION b m	IMMERSION Angle E from N °	EMERSION Greenwich C.T. h m	EMERSION a m	EMERSION b m	EMERSION Angle E from N °
Mar.	2	9 Gem	6.3	4 46.9	−1.3	−0.1	53	5 25.4	+0.6	−3.0	337
	4	ζ^1 Cnc	5.1	9 0.2	..	..	39	9 17.2	..	..	2
	6	o Leo	3.8	5 2.1	..	..	51	5 26.3	..	..	17
	10	*q* Vir	5.4	1 41.9	−0.6	+0.9	108	2 49.2	−0.6	−0.2	315
	14	31 B.Sco	5.4	7 12.1	..	..	176	7 42.6	..	..	219
	27	33 Tau	6.0	3 24.3	−0.5	+0.7	29	3 49.1	+1.2	−2.7	329
	28	99 Tau	6.0	3 5.8	+0.3	−1.9	126	3 52.6	−0.1	−0.7	245

OCCULTATIONS VISIBLE IN LONGITUDE +91° 0′, LATITUDE +40° 0′.

Mar.	2	8	Gem	6.1	4	18.2	..	..	34	4	40.8	..	..	358
	2	9	Gem	6.3	4	23.6	—1.4	—1.0	90	5	32.5	—0.5	—2.1	302
	2	36	B.Gem	6.0	8	35.0	—0.1	—0.3	53	9	8.0	+1.0	—2.1	333
	4	ζ^1	Cnc	5.1	8	55.2	—0.4	—0.9	71	9	37.7	+0.6	—2.2	335
	6	o	Leo	3.8	4	8.0	—2.2	—0.4	105	5	29.5	—1.2	—2.3	324
	14	32	B.Sco	5.4	6	13.4	—1.3	+2.3	68	7	6.8	—0.1	—0.6	330
	14	50	B.Sco	6.4	12	44.8	—1.8	—1.3	109	14	2.6	—1.1	—1.0	255
	27	33	Tau	6.0	3	17.6	—0.4	—0.5	65	4	7.4	+0.4	—0.7	294
	28	99	Tau	6.0	3	25.4	..	..	175	3	36.9	..	..	197
	29	1	Gem	4.3	6	5.1	+0.8	—2.4	154	6	37.0	—0.1	—0.2	230

OCCULTATIONS VISIBLE IN LONGITUDE +120° 0′, LATITUDE +36° 0′.

Mar.	2	8	Gem	6.1	3	0.2	—2.4	+0.3	90	4	28.6	—2.1	—1.4	292
	2	9	Gem	6.3	3	40.4	—1.9	—2.4	135	4	56.1	—2.6	+0.5	250
	2	36	B.Gem	6.0	8	32.5	—0.3	—1.3	101	9	31.6	+0.2	—1.6	292
	4	10	H.Cnc	6.1	3	24.6	..	..	39	3	50.0	..	..	4
	4	ζ^1	Cnc	5.1	8	42.0	—0.8	—1.8	118	9	50.1	—0.4	—1.9	296
	6	o	Leo	3.8	3	25.7	—1.1	—1.6	149	4	36.3	—2.1	+1.1	266
	7	155	B.Leo	6.5	1	24.4	+0.1	+2.4	69	2	8.5	—0.4	—1.5	338
	13	47	G.Lib	6.1	8	6.1	—1.1	+0.9	101	9	21.1	—1.1	—0.2	309
	14	50	B.Sco	6.4	11	45.7	—2.0	—0.6	124	13	13.4	—2.5	—0.1	262
	17	154	B.Sgr	5.9	14	42.4	..	..	12	15	22.8	..	..	319
	26	47	Ari	5.8	4	18.9	—0.3	—0.6	74	5	12.6	+0.2	—1.1	273
	27	33	Tau	6.0	3	3.8	—0.9	—1.6	108	4	7.4	—0.9	—0.5	250
	27	161	B.Tau	6.5	4	49.7	—0.2	—1.4	104	5	45.1	—0.1	—0.8	257
	28	315	B.Tau	6.3	1	34.7	—2.3	+1.1	60	2	43.5	—1.4	—2.5	305
	29	412	B.Tau	6.0	1	39.9	—2.6	+1.6	60	2	46.9	—1.5	—3.1	319
	31	209	B.Gem	6.1	4	10.4	..	..	51	4	45.5	..	..	3

The quantities in the columns *a* and *b* are given for the purpose of making these predictions useful for any place within 200 miles of the point indicated. The procedure is as follows: Subtract the longitude of the point given from the longitude of the place in question; multiply the result, taking the signs into account, by the quantity under *a* for the star to be observed; similarly, with the latitude, using *b*; apply the sum of the products, with its proper sign, to the Greenwich C.T., and obtain the predicted Greenwich Civil Time for the phenomenon at the place of observation. To obtain Eastern Standard Time it is necessary to subtract five hours; Central Standard Time, six hours, etc.

METEORS AND METEORITES

Meteor Notes from the American Meteor Society

By CHARLES P. OLIVIER, President

The last quarter of 1935 furnished two brilliant but restricted meteor showers. It is a matter of great regret that they were not observed extensively: our only reports come from one observer of each, fortunately both persons trained in astronomy and fully able properly to record what was seen. In publishing these accounts we sincerely hope that others who were witnesses will communicate with us, so that the area of the earth's surface over which the showers were active may be estimated.

For the first, we are indebted to Miss Margaret Whitcombe, a graduate of Mt. Holyoke College, who on the evening of October 19, 1935, was driving in an open car on Mt. Desert Island on the coast of Maine. She reports that she and her companion noticed more meteors than usual in the southern sky from 9:00

o'clock on. At 10:30 several bright meteors shot across the sky at once. Realizing that a meteor shower was in progress, they stopped the car and began counting meteors. In the first five minutes one observer saw one meteor in the north and the other saw seven in the south. Then both observers faced south but each counted separately. In about an hour they counted 100 bright meteors. They did not count the very faint ones. Miss Whitcombe says that she was aware of missing 20 to 30 that might have come from the same radiant to which the 100 certainly belonged. The sky was clear, observations continuous, and view somewhat obstructed to the east. Driving north at 11:30, they saw meteors still coming. In general, the meteors of this shower had vivid trains, were yellow in color, and traveled with a medium velocity.

We sent a map to Miss Whitcombe and asked her to indicate the approximate radiant. She located it at $\alpha = 40°$, $\delta = -5°$, (A.M.S. No. 2916). She says that she is not at all sure that she saw the very best part of the display, which, however, was very beautiful. As these meteors came on the night of the maximum of the Orionids, one might suspect a connection. But the radiants are over 50° apart and hence entirely different.

I have computed the parabolic elements of the corresponding orbit, neglecting zenith attraction as the radiant was derived not from plots made at the time but from estimation. The elements are:

1935 Oct. 19.67 $\quad i = 26° \quad q = 0.40 \quad \Omega = 26° \quad \pi = 307°$

I do not find in two available lists any cometary radiant near this position. In Denning's General Catalogue, Group XLI, Nos. 4 and 5 might be the same group as this shower.

Professor Mohd. A. R. Khan, of Begumpet, India, an active member of the A.M.S., writes that on November 21, $6^h\,50^m$ to $7^h\,10^m$ G.M.T., with a rather hazy sky, he witnessed a very fine shower of meteors whose radiant appeared to be near γ Monocerotis. In these 20 minutes he saw over 100 meteors, several being of first magnitude, with long trails. In the next 20 minutes he counted 11. He believes the richest part of the shower occurred earlier.

The parabolic elements for this stream, using $\alpha = 93°$, $\delta = -6°$ as the radiant, (A.M.S. No. 2917), are:

1935 Nov. 21.25 $\quad i = 75° \quad q = 0.31 \quad \Omega = 58° \quad \pi = 348°$

No cometary radiant is found for this group in any available list. In the A.M.S. Annual Report for 1925 (POPULAR ASTRONOMY, **34**, March, 1926) a similar brief and rich shower is reported for November 20, observed by F. T. Bradley, Crozet, Virginia, and by several students at the University of Virginia. I also saw the last 3 bright meteors of this shower as I left the dome of the 66-cm. refractor at the McCormick Observatory after several hours of work inside. From 2 plotted meteors I derived a radiant at $\alpha = 97°.5$, $\delta = +8°.5$, (A.M.S. No. 1623), but as I did not see the others, this position is of course uncertain. However, there is no doubt, as both radiants are only approximate, that the streams are the same: we had in 1935 a return in India of the same stream observed in Virginia in 1925, with the 1935 return much more brilliant. It seems fairly safe to say that these meteors will return in 1945. Perhaps the stream has been coming every year, but because of the short duration and apparently very narrow cross-section, it has not been observed, unless A.M.S. No. 165, seen 1904 November 18.67 could be a confirmation.

Each of these two showers (October 19 and November 21) was far richer

than any of the annual ones in 1935. The unexpected still happens, and new meteor streams are appearing, even though some of the older ones are less brilliant or lost. We hope that further information may be obtained on both these phenomena. That it is not already at hand shows that we have far too few meteor observers, despite the great increase in interest in many parts of the world.

The accompanying table gives a list of radiants derived by R. A. McIntosh of Auckland, New Zealand, Part I from his own observations and Part II from those of S. R. Fairbrother at Tadmor, Nelson, New Zealand. All the maps were sent here by McIntosh, but I have such high confidence in his skill as a meteor

RADIANTS

PART I

A.M.S. No.	1935	α	δ	No. of Meteors	Wt.	Remarks
2871	April 3.66	241°.0	—41°.5	4-5	Good	
2872	3.66	279.3	—34.5	4	Good	
2873	3.66	294	— 9	4-6	Fair	
2874	May 3.67	335.0	— 2.0	11-13	Good	η Aqr
2875	5.67	279.5	—43.8	3-4	Good	
2876	5.67	292.5	+ 2.0	4	Good	
2877	5.67	336.5	— 0.6	12	Good	η Aqr
2878	6.69	239.0	—34.8	4-5	Good	
2879	6.69	307.0	+11.5	4	Good	See 1913?, 2717
2880	6.69	324.3	—17.5	3	Fair	See 2883, 2153, 2170, 2163
2881	6.69	338.0	— 0.0	30-32	Good	η Aqr
2882	7.69	339.0	+ 0.5	25-27	Good	η Aqr
2883	7-8c	325.0	—19.0	5-6	Good	See 2709?, 2880
2884	8.73	340.0	+ 1.0	14	Good	η Aqr
2885	July 5.67	338.0	—61.0	4	Good	
2886	10.69	331.5	—32.5	7-9	Good	See 2887
2887	11.69	332.0	—31.5	12	Good	See 2886
2888	26.68	339.3	—17.3	9	Good	δ Aqr
2889	27.66	340.0	—17.0	15	Good	δ Aqr
2890	31.67	34.0	— 2.5	6-8	Good	See 2062?
2891	31.67	344.0	—15.0	6-8	Good	δ Aqr
2892	31.67	352.0	—15.5	5	Good	δ Aqr?
2893	Aug. 2.67	303.0	—15.5	4	Good	
2894	2.67	337.5	—29.0	5	Fair	Diffuse. See 2772
2895	2.67	345.6	—15.0	8	Good	δ Aqr

PART II

2896	Feb. 3.57	144.5	—56.7	4-7	Good	
2897	1-3c	206.0	—44.0	8	Fair	Diffuse
2898	Apr. 12-13c	235.0	—34.5	4	Good	
2899	12-13c	253.0	—53.5	4-6	Fair	See 2723?
2900	12-13c	282.5	—17.3	5	Good	
2901	May 3.66	262	—24.0	5	Fair	
2902	5.64	251.0	—33.0	5	Good	
2903	5.64	336.5	— 1.0	10	Good	η Aqr
2904	June 1.61	336.4	—37.5	5	Good	
2905	July 6.59	302.7	—10.5	5	Good	See 1945?
2906	6.59	336	—33.5	5	Good	Diffuse. See 1938?, 1942
2907	22.57	314.5	—20.5	4-5	Good	See 2838?, 2839
2908	22.57	337.0	— 9.0	5	Good	Possibly poor Aquarids?
2909	30.55	343.5	—15.0	8-12	Fair	Diffuse; δ Aqr
2910	Aug. 30.59	339.0	— 5.5	5	Good	
2911	30.59	13.5	— 9.5	4	Good	See 2913
2912	31.56	5.0	— 4.3	4	Good	
2913	Sept. 1-2c	13.5	— 9.5	5-6	Good	See 2911
2914	1-2c	16.5	—17.7	4	Good	
2915	1-2c	27	— 5	7-8	Good	

observer that I feel that it is wholly unnecessary to check his radiants. The coordinates are therefore given as he reported them. In accordance with our recent practice, however, most radiants determined from only 3 or 4 meteors are excluded.

We request all members of the A.M.S. and all who coöperate with us to send in without delay their observing records for 1935, so that their correct total may be given in our annual report, which will probably appear next month.

Flower Observatory of the University of Pennsylvania,
Upper Darby, Pennsylvania, 1936 January 15.

The Number of Meteors for Certain Magnitudes and Sizes

By C. C. WYLIE

In earlier papers we have published notes on the number of naked-eye meteors, the number of telescopic meteors, and the number of meteorites. We also published, in *Contributions of the University of Iowa Observatory,* No. 6, page 186, a paper on The Annual Deposit of Meteoric Material. In this paper, we stated that it appeared that the meteoric material in the space through which the earth is passing is distributed approximately according to the probability curve. The equation was derived for a probability curve which fitted the observational data at hand. From this curve, the annual rate of fall of meteoric material was derived.

As only a limited amount of useful observational data is at present available, the curve cannot be considered exceedingly accurate. The fact that it does agree satisfactorily with the information at hand is, however, reason for believing that numbers derived from the curve are of the right order of magnitude. Certainly they are much better than mere guesses. We are, therefore, giving in this paper the daily or annual number for meteors of certain magnitudes and sizes. Because of the interest in meteoric craters, we are including figures for meteors hundreds and thousands of tons in weight.

Telescopic Meteors. It appears that the number of telescopic meteors increases for each successive magnitude, to fainter magnitudes than those for which we have useful observational data. The number of telescopic meteors falling on the earth per day probably runs into millions of millions at about magnitude fifteen.

Naked-Eye Meteors. Including fourth magnitude, the number of naked-eye meteors is about 24 million per day for the world. This is one of the fundamental numbers used in deriving the curve. The number of meteors of magnitude zero is about 300,000 per day.

Dropping Meteorites. The number of meteors weighing ten pounds, or more, is about ninety per year for the United States. It is about one in eight months for cities and villages in the United States. Such meteors should usually produce detonations like distant thunder, and occasionally drop meteorites weighing a few ounces.

The number of meteors weighing 7000 pounds or more is about two every three years for the United States, and about one per century for cities and villages in the United States. Such meteors should produce detonations like very loud thunder, and should normally drop meteorites. The largest dropped by such a meteor need not, however, be one hundred pounds in weight. Meteorites weighing fifty pounds or more would normally be buried too deeply for a plow to strike.

The number of meteors weighing fifty tons or more is about one every thirty

years for the land surface of the world. It is about one in five hundred years for the United States. Such meteors would fall with earth-shaking detonations, and presumably would normally drop meteorites weighing tons. The diameter of such meteors on entering the earth's atmosphere would be about seven and a half feet, if of iron, and ten feet if of stone.

Crater-producing Meteors. The number of meteors weighing 220 tons or more is about one in 150 years for the land surface of the world. It is about one in 2400 years for the United States, and one in 160,000 years for cities and villages in the United States. Such meteors should explode on striking. They should produce small craters, and destroy life near the point of fall. Meteors of this size would, however, not normally produce the destruction reported for the Siberian fall of 1908. The diameter of such meteors on entering the earth's atmosphere would be about twelve feet if of iron, and about sixteen feet if of stone.

The number of meteors weighing 50,000 tons or more is about one in 100,000 years for the land surface of the world. It is one in 1,500,000 years for the United States, or one in 100,000,000 years for cities and villages in the United States. Such meteors should produce craters similar to Meteor Crater in Arizona, and destroy life over a very considerable area.

Comments. As far as we can tell from the information at hand the numbers given are of the right order of magnitude. For example, the ninety meteors per year, of weight ten pounds or more for the United States means about seven per year visible from one point. The number of shadow-casting and detonating meteors observed by residents of Iowa City agrees satisfactorily with this figure. Some may think more meteorites should be recovered. But we know that the chances of recovery are negligible unless a meteorite (a) strikes a building, (b) falls in a well-used path, (c) falls on a lawn, or (d) falls by day near enough some person to attract his attention. Even when a meteorite is picked up by some person, the chances are very much against its reaching scientific investigators.

Some may think that, if meteors weighing many tons are as frequent as our curve indicates, there should be an authenticated instance of such a fall. Of course many meteorites weighing tons have been found, but the date of fall is known for none of these. We must, however, keep several facts in mind. First, as is indicated in an earlier paragraph, such meteors are not nearly as large as a person would naturally assume. Second, all the larger pieces would normally be buried many feet deep. Third, the tendency of human nature to exaggerate, causes scientific men to look with skepticism on any report of a meteor weighing tons. These men know that several generations of workers have been regularly investigating such reports, yet the largest meteorite for which the date of fall is known weighs less than half a ton. It appears that very few reports of meteoric falls were investigated at all before 1800. The fall of stones from heaven was generally believed impossible. For only a few falls previous to this date was sufficient investigation made to establish the authenticity.

The figure for 220-ton meteors suggests that several small craters have been produced within the past 5000 years in countries where civilization is now on a high plane. The fall of such a meteor would naturally be described as a fall of fire, rather than of stones, from heaven. Historians should therefore be on the watch for stories of fire falling from heaven (see the Genesis account of the destruction of Sodom and Gomorrah); and geologists should make a study of depressions similar to the known meteoric craters.

University of Iowa, January 20, 1936.

Contributions from the Society for Research on Meteorites

Edited by FREDERICK C. LEONARD, President, *and* H. H. NININGER, Secretary

The Meteorite Fall of August 10, 1932, near Archie, Cass County, Missouri

By H. H. NININGER

Several references have been made to the Archie, Missouri, meteorites by those who visited the location briefly, soon after the fall occurred. The following account is presented chiefly for the reason that the writer made a more extended investigation than the others who have reported and because certain aspects of the fall thereby came to his attention which had apparently escaped the notice of those whose visits were of much less duration. It has developed also that our conclusions as to the direction from which this meteorite arrived are to some extent at variance; therefore, the following account should be given, if for no other reason than to show how great care must be exercised in the plotting of meteor paths, if any degree of dependence is to be placed upon such reports. Some of the salient facts regarding this fall have already been published by Professor C. C. Wylie in the January, 1933, issue of POPULAR ASTRONOMY (**41**, pp. 55-6). Mention of the fall is made by him also in the June-July number of the same year (**41**, pp. 340-3).* It is unfortunate that Professor Wylie and his helpers were unable to spend more time in the vicinity, for otherwise it is reasonable to suppose that our conclusions would be better coördinated.

My first visit to the locality was made early in January, 1933, when I spent two days interviewing such witnesses of the fall as were accessible, and in examining the stones which had been collected. It was impossible to spend more time on this occasion, but I had already discovered that there were discrepancies in the reports, which needed to be cleared up, and so the matter was presented to the United States National Museum. Under the joint auspices of that institution and the Nininger Laboratory, I returned to the scene the following April, and spent ten days with headquarters in the village of Archie, going very thoroughly into all of the details witnessed by the local citizens. Five public addresses were given to enlighten the citizenry on the basic facts regarding the fall of meteorites. More than a thousand persons were thus informed in the villages of Archie, Harrisonville, Adrian, and Austin. In this way, I was brought into contact with hundreds of eyewitnesses of the fall, from among whom those were selected who, on personal interview, demonstrated their fitness for making careful observations and whose situation had been such as to insure an unobstructed view of the meteor. Finally, after gathering all of the information locally that seemed to be necessary, the point of fall was encircled on a radius of 20 to 50 miles, witnesses being interviewed all along the way in order definitely to establish an approximate point over which the meteor had been seen to pass. Experience has taught me that for a person to say that a meteor passed directly overhead, may mean that it passed in a course which lay anywhere from 30° on one side of the zenith to an equal distance on the opposite side; but when finally two communities are located, 10 to 15 miles

*Reference should be included likewise to the interesting paper by Professor E. S. Haynes in these CONTRIBUTIONS, *P.A.*, **43**, pp. 181-4, March, 1935, to the sixth paragraph of the "Report on the Third Annual Meeting of the Society," in *C.S.R.M., P.A.*, **43**, p. 463, August-September, 1935, and to the short article by Professor Wylie in *P. A.*, **43**, pp. 657-8, December, 1935.

apart, the residents in one of which agree that it passed to the south of the zenith, while those in the other community agree that it passed slightly to the north, we may be sure that it passed somewhere between the two places. In securing this information, it is very important that each witness be taken to the spot from which his observation was made and that, while pointing out the meteor's course, he face in the same direction as he was facing when the moving object was observed. As the line over which the meteor passed is approached by the investigator, he finds that there is less and less certainty in the minds of some witnesses as to the exact line of passage. He should therefore be very slow to draw conclusions and should interview a large enough number of individuals to make sure that there can be no mistake.

While encircling the end-point of the Archie fall, there was little difficulty in establishing the fact that the meteor had passed to the northwest of Pleasanton, Kansas, and it was with equal facility established that it had passed to the southeast of La Cygne, Kansas (the two towns are about 14 miles apart); but when it came to establishing the exact line over which it had passed, this was not easy, and we have never been certain about this. It would of course be possible to use the altitude readings given by witnesses in the two towns, and, by calculations based on a certain assumption as to actual height, arrive at a very "accurate" location; but no purpose is served by fitting into a mathematical formula what are admittedly inexact records. It seems to the writer better simply to say that the meteor arrived from between 35° and 40° south of west, or that it came from about 37½° south of west. In certain other surveys it has been possible to reach more exact conclusions, and in the future, when the public has been educated to the point where more kodaks will be used on meteor clouds, we may be able to describe all falls with greater accuracy than has been possible up to date. The angle of descent, also, is more or less problematical, but by virtue of the careful observations of Mr. Silas Todd and two or three others, we may be about as accurate in our estimate on this point as we are on the direction previously described. The descent of the meteor was at an angle of approximately 23° to the tangent drawn at the point on the earth's surface directly under the end-point of the meteor's visible course.

The direction of the Archie fall is very important, for, as will be noted from the date of its occurrence, the time might indicate that it was part of the Perseid shower. Apparently, there was a rather determined attempt made by certain representatives of the daily press to make it appear that the meteorites had been classed as Perseids by the early investigators. So far as I can learn, however, no scientist ever finally committed himself on this point. It becomes perfectly clear, however, that the meteorites could *not* have been Perseids, since they arrived from the southwest at 3:00 o'clock in the afternoon: essentially the same conclusion has been reached by Wylie and by Haynes (*loc. cit.*).

The Archie meteorites have furnished some data which are of importance. The end-point of the cloud produced was about 11 to 14 miles above the earth's surface. Its visible length was about 40 miles and its diameter probably 1000 to 2000 feet. This cloud was visible from points as distant as 50 to 75 miles. It should be remembered that the visible length of a cloud lying 14 to 50 miles above the earth's surface is not in reality its full length by any means. A cloud must be of considerable size to be seen from distances of 50 to 75 miles, and if it narrows toward its upper end, there may be a considerable portion of it invisible. Though it remained visible for perhaps 15 to 20 minutes, no one made a photograph so far as has been learned. An enlarged puff on the lower end of the cloud was described

by many. Several persons described also tongues of "smoke" which grew out of the enlarged end of the cloud in various directions while they watched it. All of these persons insisted that this phenomenon was occurring while they were listening to the detonations from the meteor. In fact, in most cases where this was reported, the detonations were what first commanded the attention of the observers. This fact would mean that the action just described continued at least one or two minutes after the disappearance of the fireball; therefore, it could not have been the scattering of "smoking" fragments from the bursting point, for the fragments were by this time well on their way to the ground. The phenomenon can be explained as the dust from the cloud, following in the wake of the various fragments, each of which made a sort of whirlwind effect by its rapid passage, so that even though it had ceased to burn, a "smoke trail" followed it. This effect, however, should not be confused with the cloud which was produced during the meteor stage: the former was merely a follow-up phenomenon in the wake of a non-burning meteorite. Fragments do sometimes burn after the final bursting of the meteor and thereby produce individual, divergent "smoke trails" or "tongues of smoke," but in such cases the growth of the trails is much more rapid and takes place in connection with the bursting of the main meteor; it ceases long before the detonations reach the earth. Indeed, it is probable that the tongues of smoke described in the present instance each originated in this manner; but this phase was not witnessed by any except those who saw the fireball. The much slower extension of these tongues of smoke continued for some minutes, and was thus observed by those who were attracted by the detonations.

Mr. G. W. Weseman, 2 miles east and 1½ miles north of Archie, was in his yard and was attracted by what seemed to be a heavy clap of thunder. He was astonished by this, for the day was clear. Shortly after, he felt a number of small particles strike his shirt and hat and heard them falling like small hail. His little boy, who was playing alone, ran into the house and told his mother that it was hailing. An older son, Francis, a senior in high school, was hunting on the creek one-half mile to the southwest. The "boom" startled him, and then he heard "buck shot" falling among the trees, accompanied by a splash in the creek, of a chunk the size of his fist. He became uneasy and left for home.

Mr. Harry Christiansen, 1½ miles east of Archie, was working at the windmill some 30 paces from his house, when the noise drew his attention to the small, angry-looking cloud high in the western sky. He walked to the edge of the east porch and called his sister, who stood in the doorway as he discussed the peculiar phenomenon, still watching it over the comb of the house. Suddenly there came a whizzing noise and a half-pound stone landed about 5 or 6 feet to the east and a little to the south of the spot where he stood. This stone sank half its depth into the compact soil. He started for the door, then turned, and picked the missile up. He found it cold. As he went into the house, he heard another stone strike by the corner of the house and still another one fall, farther out in the yard. The second stone was found later, but the third one was not.

Mr. M. E. Miller was about one-fourth mile southeast of the Christiansen house, standing at the woodpile with a neighbor. Their account of the cloud and the noise was in agreement with Mr. Christiansen's, except in that they located the phenomenon a little farther to the south. They, too, heard stones "buzzing" through the air, followed by a thud. They found a 14-ounce stone in the road about 5 yards to the southeast of where they had stood. It had dented the hard dirt road, but had bounded out of the depression, and lay beside it. Later two other stones were found in the field within a hundred yards or so. To the north-

east, 1½ miles, a small stone was found in the path that led to the mailbox in front of a house.

Mr. George Morris was 3½ miles east and one mile north of Archie. He was doing some decorating in the cemetery and had an unobstructed view. As he watched the cloud, he was attracted to what he first thought was a swallow flying, but soon noticed that the small black speck was traveling downward in a spiral course. At about the same time he noticed another, somewhat larger speck falling in a straight oblique line and faster than the first. An 8-pound stone, found by Mr. Ralph Hodge, about a mile from where Mr. Morris stood, was just about in line with his observation as recorded by the writer before he (Morris) had learned of Hodge's find. Hodge's stone is in the form of a low, eccentric cone, which might have given rise to such a spiral flight as was described by Mr. Morris. The 8-pound stone, though it landed in a cultivated field, was not buried, but lay on top of the soil. Probably the spiral course of the stone, together with its peculiar shape, was responsible for its skidding or ricocheting instead of penetrating the soil. No stone was found in line with the larger body seen to fall by Mr. Morris. It is probable that this stone, if such it was, buried itself out of sight. A farmer in about the right location for it told me in April, 1933, that when he was "discing" his field in the preceding February, he had noticed a hole about a foot across, but had gone right over it without thinking what might have caused it. Unfortunately, he could not re-locate the spot for me.

A remarkable thing in connection with this fall is that nearly every one of the stones recovered was seen to fall near some person. The population in this vicinity averages about one family to each 80 acres. So far as could be learned, only about one person was abroad for each 40 acres in the area of the fall, and yet only two of the seven stones found were not seen or heard to strike. All of the stones recovered indicate that they are fragments of an aërially disrupted mass. In view of these facts, one would expect that a large shower had occurred; yet a very serious effort was made to discover more stones without success. It may be that one principal mass buried itself deeply in a location where the hole was not noticed, and that the stones found were merely fragments of this; or, what is more probable, in the light of the showering of fine particles reported, the main mass of the meteorite may have been crushed or shattered at the point where the fireball vanished and where the round puff of "smoke" appeared, and only a few fragments survived. Guests at the home of Mr. Jake Fortner, 6½ miles northwest of Archie, reported hearing a rain of small stones in the adjoining corn field, but they knew nothing about the appearance of meteorites, and when a brief search was made, they were deceived by finding some very light-colored porous lime stone and concluded that their search had been successful. No other search was made until my visit in April, 1933. Heavy rains had occurred meanwhile. Here, as is generally the case, we have reason to regret that no adequate search was made at the proper time, and that, as a result, we are deprived of the information which this fall should have afforded us, in view of its probable magnitude.

It is interesting to contemplate that a ton of stony meteoritic fragments, averaging the size of wheat grains, could be scattered over one square mile, or 640 acres, and yet their presence would not attract attention. This material would be only about 1/30 to 1/50 as abundant as are wheat grains, when they are distributed in sowing.

The original (interior) color of the Archie meteorites was gray, but, after exposure for a few days, the aërolites became stained brown with rust, which rendered them very difficult to find, even when a search was made. In this case,

however, we know that no search was ever made for the purpose of ascertaining whether a showering occurred. The showering which was reported at three locations probably actually took place. The fact that two of these locations were one-half mile apart and a third was 6 miles away suggests that the showering may have extended over a much larger area than one square mile.

The evidence that a large mass was reduced to dust and fine particles in the case of the Archie fall is not conclusive, but there is surely no evidence to the contrary. The accompanying cloud and its behavior, together with the rain of particles reported by six different witnesses in three different locations, and the fragmentary nature of all the stones found, are strongly suggestive.

May we hope that in the not too distant future the great importance of thorough surveys immediately after each fall has occurred shall be recognized by our various institutions of higher learning and that those who may be privileged to visit the site of such falls shall be enabled to exhaust every possibility of search!

The largest mass recovered from the Archie fall is preserved in the United States National Museum, Washington, D. C. Other stones are preserved in the Field Museum of Natural History, Chicago, Illinois, the Stuart H. Perry collection, Adrian, Michigan, the Frederick C. Leonard collection, Los Angeles, California, and the Nininger collection, Denver, Colorado.

Secretary's Office: Nininger Laboratory, 1955 Fairfax Street, Denver, Colorado.
Editorial Office: Department of Astronomy, University of California at Los Angeles.

VARIABLE STARS

Variable Star Notes from the American Association of Variable Star Observers

By LEON CAMPBELL, Recorder

New Observers: Señor L. E. Erro, a journalist of Mixcoac, D. F., Mexico, is a new, and our sole, observer in Mexico, observing with his 4½-inch equatorially mounted refractor. Mr. William Albrecht reports as another contributor of the observing group in Milwaukee, Wisconsin. Miss Hudson and Messrs. Kitchens and La Fon, students at the University of Oklahoma, under the guidance of Professor Hassler, have also communicated observations. Two more student observers from Mount Union College, Messrs. Lapp and Trautman, have joined that observing group under the direction of Mr. Walter Haas.

Recent A.A.V.S.O. Publications: Predicted Dates of Maxima and Minima of Long Period Variables for 1936 have been issued to active observers. The Julian Day Calendar for 1936, formerly printed and distributed by the late Mr. John H. Skaggs, has been printed by the Association. A few additional copies of these remain for distribution to interested observers, while the supply lasts. The A.A.V.S.O. Reprint for 1935—the last to be issued—has been mailed to active observers and interested astronomers in this country and abroad.

Regional Advisors: The following active members, because of their long experience in the observing field, have been appointed Regional Advisors for the different sections of the country—Harold B. Webb, for New York City and vicinity; David W. Rosebrugh, Eastern New York State; Caspar R. Gregory, Central

New York State; Lewis L. Doolittle, Connecticut; Leo J. Scanlon, Western Pennsylvania; Morgan Cilley, Virginia and West Virginia; Paul S. Watson, Maryland; Leslie C. Peltier, Ohio; William Callum, Illinois; L. E. Armfield, Wisconsin; Tilton C. H. Bouton, Florida; Joseph Meek, Arizona; Oscar E. Monnig, Texas; D. F. Brocchi, Washington; R. E. Millard, Oregon; Henry Raphael, California; and Mrs. Helen S. Hogg, Ontario, Canada. It is the duty of these advisors, when requested by the Secretary or the Recorder, to give assistance to applicants for membership in their respective zones. Temporary Regional Advisors will be appointed from time to time to look after candidates in other localities.

R Coronae Type Variables: Of the four best known irregular variables of the R Coronae type, at least one appears to be below normal maximum brightness at any one time. SU Tauri is perhaps on its way to another minimum. In September, 1935, it was fainter than magnitude 14.5, while in October and November it gradually increased to the tenth magnitude. At the present time it has decreased again to below magnitude 11.0.

R Coronae Borealis, 154428, has almost reached its normal magnitude of 6.0, while the two southern variables of the same type, S Apodis, *145971*, and RY Sagittarii, *191033*, have been at maximum for some months past.

In the forthcoming list of variables to be discussed by Miss Henrietta H. Swope, in the Harvard Milky Way Fields 187 and 233, two new variables of the R Coronae type are announced. These are W Coronae Australis and Harvard Variable 7203,—Coronae Australis, separated by only a degree in the sky, and varying in magnitude from 11.0 to fainter than 16.5. These present many similarities to their prototype, R Coronae Borealis: a large range in variation, long periods of inactivity at or near maximum, and long periods of marked activity at or near minimum. The addition of two more such variables to the R Coronae Borealis class is a distinct contribution to our knowledge of these apparently exceedingly rare stars, less than a dozen having been assigned definitely to this class.

SS Cygni Type Variables: SS Cygni, 213843, reached maximum (No. 282) early in January—seven days later than predicted. This maximum was evidently of the "A" type—rapidly increasing—since the light increased from 12.0 to nearly the eighth magnitude in two days. Sufficient observations have not been received as yet to ascertain whether this maximum is of the narrow or broad type.

SS Aurigae, 060547, was at maximum (No. 185) late in November. The increase from magnitude twelve to eleven was much slower than is usually the case with this variable, although not unprecedented in the case of its prototype, SS Cygni. Five days were required for the variable to increase from the fourteenth to the eleventh magnitude. The maximum was of the broad type, twelve days being required in passing from magnitude 12.0 on the increasing side, through maximum, to the corresponding magnitude on the decreasing side.

U Geminorum, 074922, was at maximum late in October, but observations were too scanty to determine more facts than that the maximum was a wide one and the variable reached the ninth magnitude.

Recent observations by our observers appear to confirm the identity of UV Persei, X Leonis, SU Ursae Majoris, AY Lyrae, EY Cygni, and RU Pegasi, as being of the SS Cygni class. Many more observations are required though, for us to determine their average periods and forms of light curve. Practically all of these variables can be observed only by those observers having instruments of large aperture.

Miss Swope appears, also, to have added two more variables to the SS Cygni

class. These are — Arae, *172562*, range 13.0 to less than 16.5, and — Sagittarii, *175434*, range 13.7 to less than 16.5.

Z Camelopardalis Type Variables: The designation of this type of variable, as distinct from the SS Cygni type, was made by Felix de Roy, because of the fact that for several months at a time this type of variable remains at a nearly constant magnitude, approximately half way between maximum and minimum brightness. To date, this class is limited to only two variables—Z Camelopardalis and RX Andromedae. Curiously enough, these two stars have approximately the same limits of brightness, with a range of about three magnitudes and an average period of 23 days and 15 days, respectively. It would be interesting to note whether or not some of the variables suspected of being of the SS Cygni type may not eventually prove to belong to the Z Camelopardalis type, having relatively short periods and stages of quiescence lasting several months.

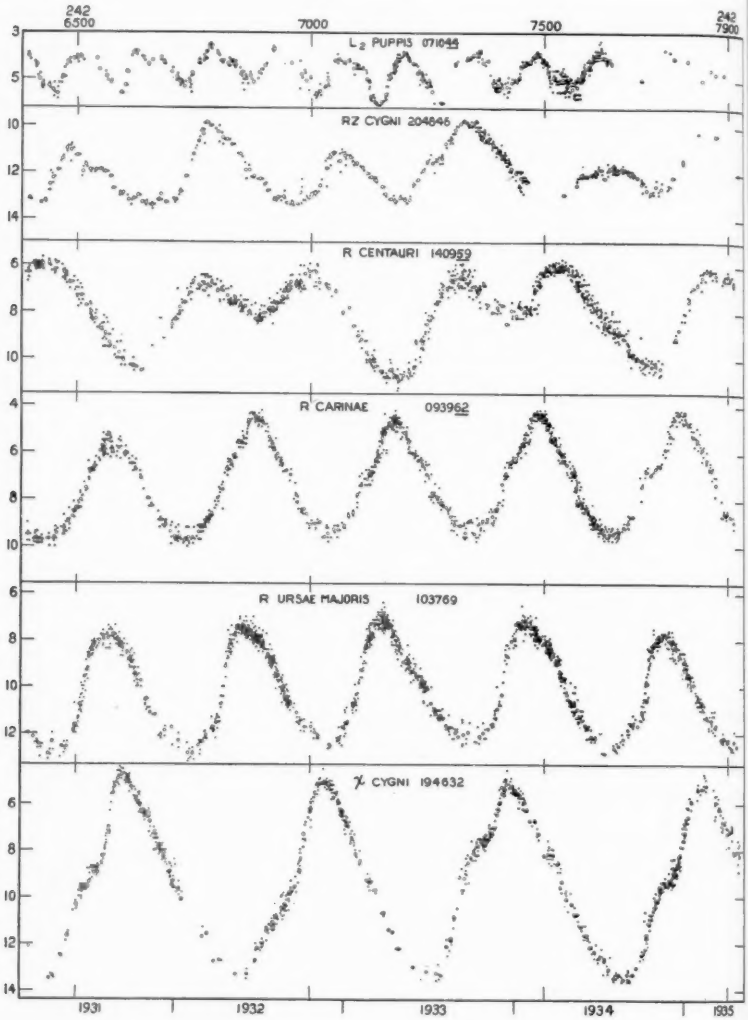
Old Novae: Several of the old novae have been more or less continuously observed during the past year by those having large telescopes, with the following results, summarized for 1935:

Name	Designation	Magnitude
Nova Persei	032443	12.7 - 14.2
Nova Tauri	051316	14.2 - 14.9
Nova Geminorum	064832	.... - [13.5
Nova Sagittarii	*181425*	.... - 14.0 (±)
Nova Sagittarii	*182529*	.... - 14.0 (±)
Nova Aquilae	184300	10.5 - 11.3
Nova Lacertae	184929	.... - [14.5
Nova Cygni	195553	13.3 - 14.8
Nova Lyrae	223152	.... - 14.5 (±)

A majority of these novae varied irregularly between the magnitudes cited, as is typical for the later stages of novae.

New Naked-Eye Eclipsing Variables: The star 29 Canis Majoris has long been known as a spectroscopic binary but it remained for Dr. S. Gaposchkin, in November, 1935, to prove that it is also an eclipsing binary. The range is small, to be sure, but the Harvard plates contain sufficient material to establish the variability to the extent of a third of a magnitude and its period as 4.39 days, the latter in close agreement with the spectroscopic value of the period. The mean visual magnitude is 4.8 and the two minima—the light curve closely resembles that of W Ursae Majoris—are essentially of the same depth. Dr. Gaposchkin computes the total mass of the system of 29 Canis Majoris to be seventy-one times that of the sun, its radius twenty times the sun's, and the mean density only 0.004 that of the sun. The absolute magnitude of the star is —7.0. It is thus intrinsically one of the brightest of the eclipsing variables and accordingly, very distant, with a parallax of only 0".0006 and a distance of about five thousand light years.

Light Curves: A plate showing light curves of six variables of long period in addition to those published in POPULAR ASTRONOMY for January is shown herewith. Particular attention is called to the secondary minima of R Centauri. There are very few stars of this type, R Normae, *152849*, being the variable that most closely resembles R Centauri. RZ Cygni appears to present a secondary maximum and might almost be considered the antithesis of R Centauri. The light curve of χ Cygni is of particular interest because it has the largest range in variation of any of the stars on the A.A.V.S.O. observing list and it presents marked peculiar-



ities on the increase to maximum. At times, no still-stand is noted, while at other times, the still-stand is very pronounced and seldom occurs at the same magnitude. As in the plate previously published, individual observations are represented by dots, and ten-day means by small circles.

January 18, 1936.

Variable Star Work in the U. S. S. R. (Soviet Union)*

Twenty years ago, the appearance of two new stars in the constellations Aquila and Cygnus aroused the interest of amateur observers in the stars which vary in brightness. When the new stars had considerably decreased in brightness, so that they could not be observed with the naked eye or modest instrumental equipment, the attention of the amateurs was transferred to variable stars. Both the Moscow observers and the Leningrad group began intensive observations of variables. In this way the nucleus of an observing group, and of a record of observations, was built up.

Moreover, not content with the observation of bright stars, they have developed their work towards a complete grasp of the problem, inspired by the general tendency toward thoroughness that is found in the work of the Soviet Union. Most of the workers are university graduates, and have already become competent specialists in variable star work.

The project, which was first in a chaotic condition, has now developed into a more systematic program, covering all the observatories that are concerned with the problem of variable stars. The necessity for discussion and meeting among the workers has been crystallized in the organization of annual conferences, not only of observers but of theoretical men. The first of these was held in Gorki (Nijni Novgorod) in 1930, the second in Pulkowa in 1932, the third in Moscow in 1933, the fourth in Leningrad in 1934, and the fifth in Kasan in 1935. The conference usually consists of three parts: reports on work done; scientific lectures; and planning of work and distribution of instructions for the next year.

The chief point of interest is the observation of long-period galactic Cepheids. According to this plan it is aimed to obtain two hundred observations of each star in five years, chiefly by the Observatories at Tashkent and Moscow. All the observations are visual, because there is little photographic equipment available for the work.

The Observatory of Engelhard in Kasan leads the "Algol Star Service," relating to eclipsing stars. There the information concerning desirable observations of eclipsing stars has been compiled. This has been published in part as a *Bulletin of the Engelhard Observatory*. At the present time plans are being made for the reobservation of all eclipsing stars, with a view to improving the elements. There is a more extended plan for the systematic computation of orbits. For this purpose accurate photometric programs are being organized, though on a limited scale at present.

Under the leadership of Pulkowa Observatory the regular "U Geminorum Service" is carried on. Some southern observatories are taking part in this work.

Especial remark may be made concerning the excellent observations of Florja, who has attained a very high accuracy in photometry, using extra-focal images and a Rosenberg photometer in visual work. At present he is working on two programs at Tashkent Observatory: first, the establishment of sequences of comparison stars; secondly, forming a photometric comparison scale, using all stars brighter than the fifth magnitude. The error of one observation is $\pm 0^{M}.02$.

The "Antalgol Service" is especially intensive; it is supervised by the writer. The program includes all cluster type stars brighter than $12^{M}.0$ at maximum that are not in globular clusters, at least two hundred observations for each star in a

*Translated by Sergei Gaposchkin.

year. In 1932 we received 13,000 observations; in 1933, 17,000; in 1934, 15,000; altogether more than 45,000. The plan further provides for a preliminary reduction of all observations made, and the formation of a catalogue of elements; some of the stars appear to have variable periods, and this work assists us in selecting interesting stars for further study.

Quite a number of statistical investigations have been completed. Kukarkin and Florja have discussed variable periods, and found that there is a numerical connection between the period and its change. The same phenomenon has been found by the author for the cluster type stars.

Two beautiful pieces of work have been done by Kukarkin and Parenago on Nova-like stars. In one of these they establish that the U Geminorum type belongs with the white dwarfs. In the second they find a connection between the range of brightness and the length of cycle. In the near future they predict the increase of T Coronae Borealis.

The author of the present note is engaged in recalculating the tables of Russell and Shapley for eclipsing stars. The theory of darkening has become very complicated.

Statistical work by Mustel shows that the Tikhoff-Nordmann effect (difference between photographic and visual minimum for eclipsing stars) depends chiefly on the mass of the stars, and is caused by the effect of tidal distortion.

Most of this work has been published in the journal "Veränderliche Sterne," edited by Kukarkin and Bortschev, over forty numbers of which have appeared. The notes are published chiefly in German or English. The journal may be obtained through Kukarkin in Moscow, although the editorial center is in Gorki.

In conclusion we may mention the organization of an observatory in the Tadjik Soviet Socialist Republic, latitude 38°. The chief program of this observatory relates to variable stars. In 1934 more than 30,000 observations were made.

W. Zessewitsch.

Comet Notes

By G. VAN BIESBROECK

Comet activity is still at a low ebb. There are no comets known to be in reach of average instruments at this time. Excessive cloudy weather has curtailed the watch on the two faint comets which were mentioned last month (p. 50). Periodic Comet 1927 III (Comas Solá) was observed here last night (January 20 U.T.) as a diffuse nebulosity of magnitude 14. It is diminishing in brightness but still shows a short tail in a north-preceding direction.

Clouds or moonlight interfered with the visibility of Periodic Comet 1929 I which although fairly well placed must be very faint by this time.

Amateurs should not forget, however, that unexpected comets may appear without any warning and that it is a desirable plan to watch the sky for such occurrences, especially the evening sky shortly after sunset or the morning sky before sunrise. That is where the new bright comets have generally been found and that is where there is the least chance that photographic records would reveal the coming of a new interplanetary visitor.

Williams Bay, Wisconsin, January 20, 1936.

Notes from Amateurs

Amateur Telescope Makers of Chicago

The Amateur Telescope Makers of Chicago met in the Adler Planetarium and Astronomical Museum, Chicago, on Sunday afternoon, January 12.

George H. Olewin spoke on "Seismological Instruments." He described the construction and use of such instruments for oil prospecting and the recording of earthquakes. He drew graphs showing the amplitude and frequency of the different earth waves, both reflected and refracted. He suggested that amateur seismology might be taken up as a hobby and said that the construction of a seismograph, good enough to do useful work, would not be too difficult for the amateur. Questions and an interesting discussion followed.

After the meeting, business, program, and educational committees were formed and plans were made for activities during 1936.

1319 W. 78th Street, Chicago, Illinois. WM. CALLUM.

Cleveland Astronomical Society

One of our most successful meetings was the first of a series of lectures on January 17 at the Warner and Swasey Observatory. Dr. J. J. Nassau, Director, chose as his subject "The Spectroscope and the Stars." The spectroscope was demonstrated in actual operation. This was followed by the lecture given with lantern slides. The observatory has a large selection of slides and is constantly adding to the collection. The second lecture will deal with the variation of the brightness of stars and will be given on March 13. The telescope makers' group made up largely of members of the Cleveland Astronomical Society are very active. A film is in preparation showing the different steps in the making of a mirror. Russell has finished his 6-inch complete with equatorial mounting and setting circles. Proster has an 8-inch Pyrex disc rough ground. A 12-inch is now on the grinding machine of the President. Your correspondent has just completed an all aluminum alloy mounting for an 8-inch refractor. So Cleveland is very much on the map in an astronomical way with meetings every other Friday night.

14 Lincoln Drive, Cleveland, Ohio. DON H. JOHNSTON.

An Exhibition of the Work of Amateurs

At the convention of the American Association for the Advancement of Science in St. Louis, December 30 to January 4 inclusive, there was conducted a display of the workmanship of amateur telescope makers and astronomers throughout the States. While in many respects it resembled the exhibition held under the same auspices in 1934 at Pittsburgh, considerable new material was shown. The exhibit centered around a series of twenty 8x10-inch transparencies, including work submitted by Wm. Henry, Latimer Wilson, DeWitt Brothers, Gustavus Cook, Harold A. Lower, H. Page Bailey, Marshall Brothers, C. W. Elmer, the Texas Observers, and Woods and Watson. Included in the series were two long-exposure photographs with a 4-inch Ross-Fecker lens by Cook, one of 6½ hours duration of the Andromeda Nebula and the other of 8½ hours exposure on Deneb and the North America Nebula. Amongst the most remarkable transparencies in the booth were the half dozen plates of Spiral Nebulae in Canes

Venatici, Coma Berenices, Ursa Major, Triangulum, and one plate showing nine extra-galactic nebulae. This particular series was the work of Woods and Watson of Baltimore, Maryland, taken with their 12-inch Newtonian reflector; most of the exposures were two-hour duration. A special transparency board was furnished by the Indianapolis group of amateurs, and showed enviable plates of star clusters and portions of the Milky Way.

Particularly fine telescopes and observatories throughout the country were shown by photographs. A 4-inch alt-azimuth reflector was exhibited by Carl Hellweg of St. Louis. Included in the display were micrometer knife-edge testing devices for the Focault test, and several finished and aluminized mirrors.

A fine display of eyepiece lens construction was presented by Clark, of Langeloth, Pennsylvania, and included lenses in all stages of completion from the rough-edge blank to the polished disc. Focal length of lenses ranged from the 10-inch finder objective, to the tenth-inch high-power ocular mounted in its brass tube. Also included were a liberal assortment of grinding and polishing laps and templates for various curves and focal-length oculars. Several adjustable eyepiece sockets for telescopes were shown by members of the Pittsburgh group, and a battery of eight eyepieces represented the work of amateurs in Tacoma and Pittsburgh. Two spherometers of fine workmanship were shown by Surovec and Clark of the Valley View Observatory shops.

While it had been planned to have an amateur at work on a reflecting telescope mirror during the exhibition, through an oversight on the part of the Locksley Observatory Staff the proper materials were not provided, and for the same reason a meteorite exhibition was not included in the display. These two features would have been highly attractive to the public, had they been available, and will certainly be part of all future exhibitions of this nature, since they proved their value in the past.

Variable Star observing by amateurs was demonstrated by a series of blueprint charts and light intensity curves supplied by headquarters at Harvard College Observatory. Amateur journals throughout the country were shown, and sample copies of the leading professional magazines were shown and distributed, when available.

While the major part of the exhibit was assembled in Pittsburgh, credit for its presentation is due entirely to Carl Hellweg, Mr. Godin, and the members of Locksley Observatory for their assistance in receiving the material in St. Louis, and arranging the display, and returning the exhibit to the donors.

Pittsburgh, Pennsylvania. LEO J. SCANLON.

The Infinite Intersections of Traveling Light

Nature's most intricate, minute, and perfect process is found in the infinite intersections of traveling light, all accomplished at a speed of 186,324 miles per second. That the process exists can be demonstrated to a certainty. How the process operates is beyond human comprehension.

Light in the textbooks and generally is represented as traveling by rays or beams. A ray of light is very simply considered as coming directly from a star or source to enter our eyes or apparatus. The convergence and crossing of rays in, let us say, a lens or at the aperture of a pin-hole camera, has been naively explained by stating that the waves passing through these temporary obstructions re-form on emergence as does a sea wave passing a row of piles. This is elementary and totally inadequate. The process is vastly more complicated.

It is accepted as fundamental that in our known space light travels in absolutely straight lines and always at the same rate of speed. It needs no special training in physics or astronomy to know that a given star sends its light in all directions, barring occultations, to the confines of space with the star at the center.

Should the star be a variable or a nova the light radiating will change in intensity. These variations will travel from the star like the annular or seasonal bands in a tree trunk, except of course they are formed from the center and will move outward in effect, as spherical shells, one following the other like soap bubbles blown one inside the other, in close contact like, crudely, the layers of an onion. The light shells expand always at the same rate of speed, maintaining their radii in absolute straight lines which lengthen at the fixed speed of light, 186,324 miles per second, thus maintaining a perfect spherical form. If the shell did not, in expanding, maintain each radius in a straight line, the generating star would appear to change its position in the heavens wherever observed and stars do not so change.

Each star has a determined composite chemical content, the nature of which is registered by the various Fraunhofer lines found in the spectrum of that star.

The waves responsible for each separate one of these Fraunhofer lines have a separate continuity of their own, so that the spherical shells radiating from each given star is a complicated set of equally spaced wave shells for each separate spectroscopic line of each of that star's elements, intermixed with other differently but equally spaced shells for each other spectroscopic line of the chemical content of the given star. This relates to only one star. Continuity on continuity, one for each separate line, each of a different wave-length but all moving outward at the same tremendous speed of 186,324 miles per second with no variation and all taking place so delicately and precisely that the smallest variation in position or intensity of a single spectroscopic line would greatly puzzle the astronomers. Each other star has its like distinctive set of complicated continuities, no two stars necessarily alike. Millions of stars with continuities.

Let us choose a point out in free space. Let it be a mathematical point. With suitable telescope every star in the firmament is visible from this point, barring occultations, which means that light from every heavenly body comes to that point. Not only comes to that point, but passes through that point to continue on its way. The light intersections at the point we have selected are exactly similar to those at all other points in space, be they close to or distant from it. In fact we may say that every astronomical body in the universe is visible from every point in the universe, which means that light from every source in the universe passes through every point in the universe at every instant of time. As a corollary, light, proceeding from a star to any point, intersects with light from every other star in the whole universe at each infinitesimal point of its advance at every instant of time, and all at the speed of 186,324 miles per second. Each ray is but a radius of the complicated shells that the millions of various stars are successively emitting each instant.

This is a very involved picture to visualize and yet it is logically certain, all accomplished so smoothly and perfectly that it has not attracted the attention of ancients or moderns. That the process is carried on we readily know. The miracle of its method, the structure that permits it, lies with its Creator, who said "Let there be light." It is probably the most wonderful process in our inorganic universe, only the secret of life, perhaps, surpassing it.

Our earth revolves through space, so that our telescopes never stand still relative to non-terrestrial sources of light. They are like passengers on a moving

train. A fan-shaped beam of light is received. The first ray but an instant in duration and the next ray is taken on and so on successively, like moving the tip of a stick across a swiftly moving stream. The "ray of light" that started the Century of Progress Exposition was chosen because it originated and started from the star Arcturus, forty light years distant, at the time of the Columbian Exposition, 1893, and had been traveling earthward since that time. But during that interval the earth had also traveled its millions of miles, not only around the sun, but with the sun and its satellites in its journey through the stellar system. Finally, we met and picked from the shells of light from Arcturus, started forty years before, sufficient energy to actuate forces which set in motion the machinery of the exposition. The earth had been receiving, continuously, rays of light from Arcturus during those forty years but they were different rays, the radii of far different shells. If the starting of the Century of Progress machinery required an interval of only ten seconds, the spherical shells which carried the energy for the tenth and last second were still nearly two million miles away at the instant the experiment started.

Light undisturbed travels in absolutely straight lines. It is always a true radius of its spherical shell. Stellar maps depend upon such invariability. If there is a variance the exception calls for an explanation. Dr. Einstein has pointed out a variation in the position of stars observed near the sun during its total eclipse, due to the fact that their rays are bent so that these stars seem to have shifted. This bending of the rays he attributes to the action of gravity on them as they come within the sun's gravitational field, bending them toward the sun and thus making the stars seem to have moved away from the sun. More than a single "ray" is affected. The whole succession of light shells from these stars must be affected for the star displacement is observed and may be photographed at any spot within the umbra. The change in the light shells is such that a normal or perpendicular to their succeeding surfaces is no longer a radius of their former sphere and the source of light is seemingly displaced.

We might also note that a body which is acted on by gravity attracts any body which attracts it. If the sun attracts light then light attracts the sun. This would make light a gravitational body and light would attract light. Yet we have distinctly defined photographs of stars 300,000 light years away. With all that continuance of possible mutual attraction during their aeons of travel, of almost identical shells, the images are still distinct. If there is gravitational effect, why did not the rays drift together? Can it be that the shell has identity, has a tenacity?

Light has many unsolved problems but it seems to have suffered no evolution. The light of near stars generated a year ago or yesterday and that generated hundreds of thousands of years ago mesh silently and perfectly. Each star preserves its minutest characteristics whether picked up at the earth's position in 1870, 1900, or 1936. Millions of light shells, from all possible angles of direction, each with the unvarying characteristics of its generating star, intersect each other at 186,324 miles per second, all without a ripple that has attracted our notice. With the cosmic and other rays they seem to make no interference. Somewhere in the theories of light these intersections are a factor. These conditions must have their significance in light problems.

GEORGE N. COLE.

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Comet Seekers and Comet Seeking

Comet seeking is a fascinating branch of astronomy that especially appeals to the amateur with modest equipment. Not only is it a pleasant pastime, but if followed systematically will develop an accurate knowledge of the celestial sphere.

Many of our greatest astronomers served an apprenticeship as humble comet hunters. Messier while engaged in this work made his famous catalogue of nebulae and clusters so he would not mistake a faint nebula or cluster for a new comet. The value of this contribution to science has made his name famous for all time. Many of the masters had only very meager equipment. Argelander while making his Durchmusterung used a 2½-inch telescope. Small instruments were used by Burnham, Carrington, and Barnard while Messier himself had only a two-foot comet seeker.

To come down to recent times it is worthy of note that Peltier with many comets to his credit has used a 4-inch refractor. So if you have a desire to do something useful in astronomy do not let the lack of a large telescope stand in your way. Even a small hand telescope or a field glass or binocular is an impressive instrument of research in the hands of one who knows his star charts and particular star fields.

To the beginner puzzled by what books and star charts to obtain, I would recommend the following to start with. After these have been studied many others will suggest themselves. For a general astronomy and a very lucid one, try "Elements of Astronomy" by Fath. As a companion purchase "A Beginner's Star-Book" by Kelvin McKready. The name of this volume is rather misleading for while it is indispensable to the beginner it will also be found invaluable throughout life. This should be followed by Norton's "Star Atlas." When the reader knows the contents of these books by heart he will indeed be well informed.

Probably the best time to look for comets is just after sunset or just before sunrise. After sunset, observe the western sky close to the horizon and at sunrise sweep the eastern sky low down in the vicinity where the sun will rise. However, comets may appear in any part of the sky at any time.

When first observed a comet will likely have no tail and seem like a small misty patch of light. Observe whether it moves in the field in relation to surrounding stars. If you think you have discovered a comet, notify by wire the Harvard College Observatory, Cambridge, Massachusetts, or other nearby observatory if you are acquainted with members of the staff. Many observers have lost credit for a discovery because they failed to report promptly.

The ideal Comet Seeker is of relatively large aperture and short focal length. As the observer will probably not have an observatory we will consider a tripod portable mounting. A plain alt-azimuth mounting is about as good as an equatorial head for this use. The main essential is that it be rigid. As this type of mounting will not have circles, in describing the location of an object it will be necessary to refer to its location in reference to well known stars in the field. Here is where a good star atlas is indispensable. A finder is desirable though not absolutely necessary. However, it is convenient both to locate objects and to study a star field with low power. In this connection it is well to remark that high magnification is a delusion and a snare. The usual power required will rarely exceed 50 or 75. Of course, when a suspicious object is located it can be studied with various higher powers but often little is gained. A bright hard image is to be preferred to a large dim one.

The author prefers a refractor for this work though others may by no means agree. Possibly the choice will depend mostly on the personal preference of the

observer. A refractor is lighter to take out and set up, also easier to point. But a larger reflector can be bought for the same price.

The origin of comets is undetermined. The most reasonable explanation, in the author's opinion, is that they were formed as the sun passed through a nebulous region in the remote past. Material was collected by the sun and planets and so the local comet group came into existence. In other words the comets we see are strictly connected with our solar system. As disintegration continually takes place at every approach to the sun there will come a time when there will be no more comets to observe. In the comparatively short time of recorded human observation many comets have failed to reappear and some have broken up almost under our eyes.

N. T. Bobrovnikoff, in a paper on the disintegration of comets states (*Lick Observatory Bulletin* No. 408, 1929): "In their obedience to the law of disintegration comets form a system all members of which follow the same career with the same ultimate fate. The matter in comets must be in a very peculiar state of excitation which does not occur often in the universe. Yet all comets have fundamentally the same spectrum. These facts constitute strong evidence for the common origin of comets.

"The system of comets is closed, that is, we have no influx of fresh comets coming from the depths of the universe. If we had any, it would affect the correlation between their orbital elements and the average absolute brightness. Indeed, such correlation would be incomprehensible.

"On the other hand, this correlation shows that the disintegration of comets is an irreversible process. There is no building up of new comets from the meteoric and gaseous matter diffused in space . . . "

He then infers that comets can not be much over 1,000,000 years old. If older they would have broken up in past ages. Also that they are true members of our solar system but not as old as the planets.

But it no longer seems likely that comets are altogether the tenuous objects they were once thought to be. It was once widely held that the largest comet could be condensed and carried in the vest pocket. It now appears that the nucleus of a comet may contain many large pieces of matter ranging in size from a grain of sand to many tons in weight. That comets and meteors are related is now understood. In fact, meteor falls may be fragments of comets. Owing to the great destruction caused by the fall in Siberia in 1908 it is evident that if the earth should collide with the nucleus of a comet a very lively time might be experienced by people living on the exposed side of our planet. Happily, the chances of such a meeting are remote. That the earth passes through the tails of comets at different times seems probable. This would not be noticed at all.

That flourescence plays a part in lighting up comets seems likely. Certainly some electrical effect is present. Very little has been written on this phase of the subject but it would seem to be a fertile field for investigation.

It is good practice for the amateur to watch for the return of periodic comets whose time of reappearance and approximate location is announced in astronomical magazines in advance. It furnishes an opportunity to see what a comet looks like when faint and there is always a thrill in picking up the celestial visitor.

There is no good reason why any amateur astronomer should not be the discoverer of a comet if persistent in the search.

DON H. JOHNSTON.

Starcrest Observatory, Collins, Ohio.

Asteroid Notes

By HUGH S. RICE

From far-distant Tsinan—on the Hwang Ho, the Yellow River in China, and 200 kilometers from its mouths—there comes word to this department that we have whetted the appetites of certain students of the Cheeloo University, in respect to asteroid hunting. With reflectors, refractors, and binoculars they follow these celestial objects, and seem to be eager for more ephemerides of the planetoids for searching purposes. There is activity of a similar nature in South Africa, also in various points in this country from New England to Oregon. The commonest request is for ephemerides.

Some observers have noticed close conjunctions of Vesta with stars, as in the case of December 6, when the planet passed a star (as can be seen on our chart) at a distance of only ½′ [this was reported by Mr. Meyer of Rutherford, N. J.], and Juno passing close to a double on November 8, reported by Mr. Sanders of Baltimore, who is faithfully following several asteroids, including the Big Four and others. Planets 8 Flora, 6 Hebe, and 16 Psyche have been among the other bright ones seen.

We publish at this time of the year the total number of asteroids whose observations have been sufficient for their elements and ephemerides to have been calculated. During the last year, up to November 16, 43 new ones have been added, numbered 1302 to 1344 inclusive. The last one is known as planet 1344 [1935 GA]. The magnitudes of these range from $12^{M}.2$ for planet 1317 [1934 FD] to $15^{M}.9$ for 1312 Vassar; it seems therefore quite evident there is little chance of more bright ones being discovered. We have as yet given no indication of the immense amount of work done by the observatories specializing in the observations that make possible our final knowledge of these numerous worlds, nor of the great amount of computing undertaken by those skilled in celestial mechanics engaged in this work, nor yet of the labor involved in all these data at the clearing house, the *Astronomisches Rechen-Institut* at Berlin-Dahlem, Germany. The elements include 9 items, and the ephemerides include the positions for about 6 weeks together with some other data, and these elements and ephemerides are computed annually for an increasing number of minor planets—1344 of them for 1936, as previously noted.

Looking at the prospects for picking up the brighter asteroids this year with small telescopes, we note the following: Number 1 Ceres, the largest, comes to opposition on May 16 in Libra, with a magnitude of 7.3. Number 2 Pallas attains its opposition on April 24; it will then be in Boötes, near Arcturus, with $7^{M}.8$. It is likely that a chart of this will be published in these Notes. 3 Juno has no opposition this year, but is still to be seen in Cetus, having run off our old chart, and appearing about 2° southeast of γ Ceti and moving northeast, with brightness of $8^{M}.4$. 4 Vesta will not be seen to advantage until autumn, as it will be in opposition to the sun on December 31; it will be particularly faint for this bright asteroid, during this year's apparition.

The next brightest asteroids to be seen during the February period are 20 Massalia in Cancer, opposition February 5, magnitude $8^{M}.4$; 24 Themis in Leo, opposition February 12, $10^{M}.1$; 654 Zelinda in Hydra, opposition February 15, $9^{M}.7$; and 532 Herculina in Leo Minor, opposition February 26, $8^{M}.8$. Ephemerides of Themis and Zelinda will be furnished on request; following are the places for the other two:

PLANETOID EPHEMERIDES. EQUINOX OF 1925.

	20 Massalia			532 Herculina		
		α	δ		α	δ
	G.C.T.	h m	° ′	G.C.T.	h m	° ′
1936	Feb. 2.0	9 14.0	+14 45	Feb. 2.0	. ....	.. ..
	10.0	9 6.1	+15 22	10.0	10 43.0	+27 12
	18.0	8 58.8	+15 56	18.0	10 37.4	+28 53
	26.0	8 52.6	+16 24	26.0	10 31.0	+30 23
	Mar. 5.0	8 47.0	+16 52	Mar. 5.0	10 24.6	+31 35
	13.0	. ....	.. ..	13.0	10 18.6	+32 25
	21.0	. ....	.. ..	21.0	10 14.0	+32 52

American Museum of Natural History, New York, January 18, 1936.

General Notes

Professor E. G. Mariolopoulos has been appointed director of the Greek National Observatory at Athens as successor to Professor D. Eginitis, recently deceased.

Professor Edwin Grant Conklin, one of America's leading biologists and long a professor at Princeton University, was elected president of the American Association for the Advancement of Science at the recent meeting in St. Louis.

Mr. David B. Pickering, well-known author of the series of papers under the title "The Astronomical Fraternity of the World" is spending the winter in Daytona Beach, Florida. On January 27, Mr. Pickering gave an address on Variable Stars before The Star Gazers, an organization of amateur astronomers in Daytona Beach.

The Star Gazers of Daytona Beach, Florida, are carrying out a bi-weekly schedule of meetings this season. For February the meetings are planned as follows: February 10, "Copernicus" by Mr. J. O. Codding, and "The Constellation Lepus" by Mrs. James R. Scobie; February 24, "Stellar Distances," by Miss Leah Walters, and "The Constellation Hydra," by Mrs. J. H. Perry.

News from the Yerkes Observatory

By action of the Board of Trustees of the University of Chicago, *Dr. G. P. Kuiper* has been appointed Assistant Professor of Practical Astronomy at the Yerkes Obervatory, beginning September 1, 1936.

Dr. W. W. Morgan has been assigned to assist the Director in the administration of the Yerkes Observatory, and *Dr. C. T. Elvey* has been transferred to the McDonald Observatory to assist in the administration of the new institution.

Dr. Charles Hetzler has been appointed Assistant at the Yerkes Observatory. *Dr. Philip C. Keenan,* a member of the staff of the Yerkes Observatory for three years, has accepted an appointment at the Perkins Observatory, Delaware, Ohio. *Mr. J. A. Hynek* passed his examination for the degree of Ph.D. on September 26 and received his degree at the December convocation of the University of Chicago. He has accepted a position on the staff of the Perkins Observatory.

Professor F. E. Ross has returned to the Yerkes Observatory after a stay of several months at the Mount Wilson and Lick Observatories.

Dr. P. Swings of the University of Liège and *Dr. S. Arend* of the Brussels Observatory spent several months at Williams Bay as advanced fellows of the C.R.B. Foundation.

December 24, 1935.

Popular Astronomy Loses an Esteemed Subscriber

George Irving Hopkins died February 26, 1935, at the age of 85. He was a native of Foster, Rhode Island, and a graduate of Brown University in the class of 1875. In 1880 he came to Manchester, New Hampshire, where he taught mathematics and sciences in the high school, retiring from the principalship of the school in 1921. He was the author of the text-book "Inductive Plane Geometry," the distinctive feature of which was the demand for original demonstrations by the pupil. He was one of the founders of the Manchester Institute of Arts and Sciences where he was head of the department of Physical Science. He was also a member of the New Hampshire Academy of Science.

He took an active interest in all lines of natural and physical science with strong leanings toward geology and astronomy as favorites. His long years of teaching gave him a wide acquaintance with men of all ages who looked to him for varied items of information long after school days were over.

Such an interest demanded a library of books and current magazines of scientific character to satisfy the inquiring mind whose activity never failed up to the moment when death overtook it.

Mr. Hopkins was a subscriber for POPULAR ASTRONOMY from its beginning, and before that he had subscribed for *Astronomy and Astrophysics* and *The Sidereal Messenger*. Many institutions have maintained continuous files of this series of publications, but Mr. Hopkins' subscription, continuous since 1882, is perhaps unique for individuals.

Summary of Sun-Spot Observations at Mount Holyoke College, 1935

Month	No. of Obs.	North of Equator No. of Groups	North of Equator Av. Lat.	South of Equator No. of Groups	South of Equator Av. Lat.	Av. No. at one Obs.	New Groups
January	20	1	+30°	4	−24°	1.55	5
February	23	4	20	7	17.9	1.65	11
March	22	4	20	5	20.9	1.59	8
April	20	3	24.7	3	25.5	0.70	6
May	27	6	25	8	24	2.26	12
June	10	5	26.7	2	28.8	2.60	5
July	15	4	27	7	23.3	2.47	10
August	6	1	22	5	25.8	3.00	6
September	14	10	22.4	6	21.8	4.00	16
October	20	23	20.3	13	18.7	5.75	30
November	14	8	21.7	10	22.9	4.00	18
December	15	7	19	13	23.5	4.07	18
Totals	206	76		83			143

Average number at one observation 2.66
Average latitude of spots north of equator +22°0
Average latitude of spots south of equator −21°8

The sun was observed on 27 days when no spots were seen.

Most of the observations from January through June were made by Miss Marjory Wright; those of July and August were made by Miss Mary Hunt, an

undergraduate student; most of those from September to December were made by Miss Helen Porter.

ANNE S. YOUNG.

John Payson Williston Observatory.

Centenaries in 1936.—In the *Journal of the British Astronomical Association* for December, 1935, is found a paper by Kate Runciman Sellers in which are given brief comments concerning men, in astronomical literature, of whose birth or death the year 1936 is a centennial year.

The names given are:

Isadore of Seville (Isidorus Hispalensis), died in the year 636.
Regiomontanus (Johann Müller), born in 1436.
Jean Sylvain Bailly, born in 1736.
John Pond, died in 1836.
Jean Felix Adolphe Gambart, died in 1836.
Sir Joseph Norman Lockyer, born in 1836.
Alexander Stewart Herschel, son of Sir John and grandson of Sir William, born in 1836.
George Washington Hough, director of Dearborn Observatory, born in 1836.

Correction.—On page 31 of the preceding (January, 1936) issue, in the paragraph relating to the planet Venus, the phrases "the bright evening star in the west" and "seen as morning star in the east" should be interchanged. Also for "morning dawn" read "evening twilight."

Book Reviews

Stellar Parallaxes, by Philip Fox. *Annals of the Dearborn Observatory of Northwestern University.* Evanston, Illinois, Vol. III, 194 pages (1935).

One of the most notable achievements in modern astrometry has been the photographic determination of stellar parallaxes by means of long-focus telescopes. The classical work done along this line in the beginning years of this century by Schlesinger at the Yerkes Observatory has stimulated an enthusiastic campaign of parallax determinations in which many observatories have participated. When in 1909 Philip Fox left the Yerkes Observatory to assume the responsibility of directing the work at the Dearborn Observatory it is natural that he initiated there a parallax program with the 18½-inch refractor as the major work of the institution. The telescope which had been used exclusively for visual work up to that time had to be adapted to the photographic process. The first plates were taken in 1912 and except for an interruption of two years during the great war the program was prosecuted continuously until 1929, when Professor Fox became the Director of the Adler Planetarium. The standard methods of procedure at the telescope, at the measuring machine, and at the computing desk were used. The only departure from the established norm is the omission of the rotating sector as a means of equalizing the apparent size of the image of the parallax-star and that of the comparison stars. This meant a limitation of the program to stars within a narrow range of magnitudes; the great majority of the stars studied for parallax are between magnitudes 8 and 9. This meant also that relatively bright comparison stars were used and that the exposure times were short.

The present volume which the author inscribes to his venerable friend Henry Crew gives in their final form the results obtained on 197 stars, for which the photographic material was adequate. Up to 6000 plates have been exposed in the course of this campaign but for a good part of these the material was not complete. Only those fields for which there was an adequate distribution and number of plates were measured and reduced. The majority of the 197 completed fields refer to proper-motion stars of the later spectral types.

Comparison stars were chosen as usual from the consideration of geometric distribution and apparent brightness. Their number varies between large limits but is 4.9 on an average. Often two solutions were made with different selections or groupings of background stars. A few cases of negative dependences occur but these extreme cases which should be avoided are rare.

The introduction gives an interesting discussion of the precision of the results and of their systematic errors. It is interesting to note that although the Dearborn telescope is the smallest instrument used in the determination of stellar parallaxes the average probable error of 0".010 for the parallax is not much above the uncertainty of the results secured with larger instruments. The same result is indicated by the probable error ±0".033 of an observation of weight unity, mean of two exposures on a good plate. The characteristic tendency of the Dearborn parallaxes to be high, which had already been noticed from preliminary publication of part of the results, is again confirmed by numerous comparisons with mean values determined at other observatories, not only by the trigonometric method but by the spectroscopic method as well. No definite cause, seasonal or otherwise could be found for this tendency. But a striking effect of magnitude is brought out by comparison with individual observatories and still more with the mean of all. The apparent diameters of the parallax-star and the comparison stars on one of the plates is given for each field. If the excess of diameter of the parallax-star over the average diameter of the comparison stars is plotted against parallax-excess there is indicated a consistent trend towards greater parallax with greater difference in magnitude. And since the latter difference is positive in the majority of the cases, the average Dearborn parallax is bound to come out too high by an amount of about 0".016.

The detailed results take up the main part of the volume. Several reductions are revised from previous preliminary announcements and given here in their final form. The standard form of publication is used with perhaps more details than usual about the reason for putting the star on the program and the meaning of the results obtained. A summary of the results at the end of the volume includes the magnitude differences referred to above which will prove of great value in investigating the systematic errors attributable to that source. The author gives full credit to his many collaborators for the work at the telescope and for the lengthy numerical reduction. G. V. B.

Grundriss der Sphärischen und Praktischen Astronomie, by Friedrich Becker. (Fred Dümmler, Berlin and Bonn, Germany.)

The above is the title of a volume of 167 pages, issued in 1934. As the title indicates it is an elementary treatise on spherical and practical astronomy. It is, of course, in the German language. In the preface, the author states that he has been induced to prepare this volume by the consideration that no similar work had appeared in German since 1912, and the consideration that earlier works were not suitable for the beginner, but were designed for use by professional astronomers.

After some brief introductory remarks, the author presents the material of the

subject in four chapters: (1) Fundamentals. Celestial Coördinates and Time; (2) The Reduction of Astronomical Observations; (3) The Phenomena of the Motions of the Celestial Bodies; (4) Practical Positional Astronomy. These are in turn divided into from three to six parts, so as to center attention upon particular topics such as aberration, eclipses, stellar parallax, etc.

Numerous equations and formulae are presented, and their meaning and application carefully explained and sometimes illustrated by examples. One feels that the subject is skillfully treated in this volume and that this work will be found extremely useful for those for whom the language is not an insurmountable barrier.

Research Surveys of the Minor Planets, by A. O. Leuschner. *Publications of the Lick Observatory,* **29**, pp. XXI +519. (University of California Press, Berkeley, 1935).

The care of providing elements and ephemerides for the ever increasing number of asteroids has for years rested largely with the *Astronomisches Rechen-Institut* of Dahlem (Berlin). Several collaborators in various countries have taken over a number of these planets but the great bulk is still shouldered by the *Rechen-Institut* where there is kept on file a complete record of all the facts pertaining to this large family of objects, 1344 of which are represented in the ephemerides for 1936. Only a minor part of this information is available in published form. For a good many years Professor Leuschner has had in mind presenting in a systematic publication a critical history of the work done on each planet; on the orbit as well as on the perturbations, and on the representation of the observations. The result of his long efforts is this imposing volume, which is at the same time Vol. II of the Contributions of the Berkeley Astronomical Department. It contains a discussion of the computational material accumulated in the course of time concerning the first 1091 asteroids up to June 30, 1929. Although the work was planned a score of years ago, it did not materialize until 1926 when a grant from the International Education Board made it possible to enlist the services of Dr. H. Thiele and several assistants for carrying out the details of the publication. Other contributions and the help of many collaborators enabled the Astronomical Department of Berkeley to carry this arduous project to a successful completion.

The main part of the volume, litho-printed for the sake of economy, is prefaced by a 20-page introduction in which the author explains the genesis of the work, discusses controversial points in regard to the best treatment of the asteroid problem and gives the details of the notations, abbreviations, and references used later. For each object we find a short history of the circumstances of the discovery and of the sources of the first orbits determined; then the work that has been done on combining several oppositions and on perturbations so as to establish definitive orbits; peculiar features of the orbits and of the perturbations are emphasized; suggestions are sometimes added for the use of group-tables in developing accurate or approximate perturbations. Thus anyone can see at a glance what is the status of the work done on any particular object.

The volume will be invaluable for those who can devote their time to perfecting existing computations by taking into account special perturbations or working out the general perturbations. It will avoid duplication of efforts where economy of labor is of extreme importance and direct the choice of future investigators to places where further work is most urgently needed. There is no question but that this systematic presentation of the status of the asteroid problem will stimulate

interest in a field where there will never be too many workers. At the present rate of growth of the asteroid family it will not be many years before a second volume similar to this one, covering the material for several hundred more objects, will become desirable. But this will not detract from the lasting value of the present publication. G. V. B.

New Stars and Galactic Nebulae, by Boris Vorontsov-Velyaminov. Moscow-Leningrad, 1935.

Professor Vorontsov-Velyaminov evidently belongs to that group of modern astronomers who believe that astronomical knowledge has arrived at a most important stage. It seems to them that the astrophysical ideas of today will be fundamental to the astronomy of tomorrow. In addition, Vorontsov-Velyaminov is one of those atronomers who are able to see one problem in the light of our whole knowledge about the universe.

These two tendencies can be traced throughout his book, "New Stars and Galactic Nebulae"; they explain both the virtues and the omissions. It is neither a textbook nor a handbook, and yet there are many pages that deal with fundamental problems. The book consists of eleven chapters, entitled, respectively: I. Ordinary Stars in the Stellar Universe; II. Structure and Dynamics of the Stellar Universe; III. Atoms in Stellar Atmospheres; IV. Stars of Type O; V. Diffuse Nebulae; VI. Planetary Nebulae; VII. Physics of Gaseous Nebulae; VIII. Results of Observations of New Stars; IX. Physical Nature of New Stars; X. Unusual Stars; XI. In Search of an Interpretation. An appendix contains a catalogue of planetary nebulae. The whole book could be divided into three parts: the first 100 pages deal with general properties of stars; the next 200 pages discuss the novae and galactic nebulae; the last 20 pages attempt to interpret the origin of Wolf-Rayet stars, planetary nebulae, and novae.

The author himself has been concerned chiefly with novae and galactic nebulae, and the book contains many results that are not published elsewhere. In addition to a compilation of material on O stars, Wolf-Rayet stars, nebulae, and novae, it contains a highly interesting discussion of the data. On every page the reader is struck by the play of original ideas. It is difficult to criticize the book's content, or even to discover its final conclusion. Apparently, however, Vorontsov-Velyaminov supports the idea that planetary nebulae are the result of nova outbursts.

It is to be regretted that although the author often mentions the names of astronomers who have been concerned with the subject, he gives few references, which reduces the value of the work. A subject index also would greatly add to its value. Most English names are transliterated into Russian correctly, but some are unfortunately altered: Shapley becomes Sharply, and Hubble appears as Hewble.

The author himself describes the aim of the book as follows: "The author would like the reader who reaches the last page of this book to feel that he has tasted, at least a little, that pleasure and satisfacion he himself has felt in the writing of it, in gathering and arranging the data, and in pointing out the nebulous forms of the stirring discoveries of the future."

The book is the first to deal with the modern interpretation of novae and galactic nebulae. There is no doubt that it constitutes an important contribution to the subject, and it is to be regretted that such a work should be accessible only to those acquainted with the Russian language. SERGEI GAPOSCHKIN.

Weather Proverbs and Paradoxes, by Wm. J. Humphreys. (The Williams and Wilkins Company, Baltimore, Maryland. $2.00.)

This is a second edition of a volume under the same name published originally in 1923. The fact that the earlier edition was exhausted prompted the author to prepare the new volume. A comparison of the Tables of Contents in the two volumes reveals very little change. Only one new topic has been added in each part. The paradoxes are especially interesting and the scientific explanation of them is very instructive. The volume contains sixteen pages of excellent illustrations of meteorological phenomena such as rainbows, halos, and the various types of clouds. The book is amusing in places, entertaining, and informational.

Die Beobachtung Veränderlicher Sterne, by Dr. Rolf Müller. (Johann Ambrosius Barth, Leipzig.)

The observation of variable stars is the title of a pamphlet of twenty pages intended for the purpose of giving first instruction to those interested in taking up this phase of astronomical work. The suggestions made are clear and concise and the beginner will derive much help from this work. The process is carried through from the making of the observations to the determination of the light curve. One must, of course, understand the German language to profit by the instructions herein set forth.

In the last few pages of the pamphlet is found a description of a practical method of determining the zenith distance, developed along the lines of a paper by R. F. Boyer in the January (1935) issue of POPULAR ASTRONOMY.

Handbook of the Heavens, edited by Hubert J. Bernhard, Dorothy A. Bennett, Hugh S. Rice. (Whittlesey House, McGraw-Hill Book Company, Inc., New York City. $1.00.)

This is the second issue of a work under this title. It is more than twice the size of the first one and is printed, whereas the earlier one was in photostat form. It is sponsored by the American Museum of Natural History in New York City, and indicates the large place which astronomy holds in that institution. It contains seventeen chapters all well illustrated with diagrams, charts, and photographs, totalling eighty-five.

The elementary phases of astronomy are well presented, and one who is beginning a study of the heavens either by actual observation or by reading will find this volume helpful. One cannot mention all the details in which this is true but we feel no hesitancy in recommending the book very highly to those desiring comprehensive, compact, and authoritative information about the heavens.

Astrographic Catalogue, Hyderabad Section, Part III.

This volume is the latest increment to the literature that has been accumulating since the project of making a photographic record, an "Astrographic Chart" of the entire sky, was launched in 1887. This volume is the result of work done at the Nizamiah Observatory, and is contributed by Osmania University, Hyderabad. It contains the measures of rectangular coördinates and diameters of 65,782 star-images which are found on plates whose centers are at declination $+39°$. It as all similar volumes represents an enormous amount of labor and furnishes valuable information and useful data to workers in positional astronomy. It has great value not only for the present but will be more and more valuable as a record as time goes on.